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Report on the state of play for the implementation of the project Integrated Baltic Offshore Wind Electricity Grid Development (Baltic InteGrid) of the Seed Money Facility of the European Union Strategy for the Baltic Sea Region (EUSBSR Seed Money Facility)

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Report on the state of play

for the implementation of the project

S21 – INTEGRATED BALTIC OFFSHORE WIND ELECTRICITY GRID DEVELOPMENT (Baltic InteGrid)

of the Seed Money Facility of the European Union Strategy for the Baltic Sea Region (EUSBSR Seed Money Facility)

November 2014

Part-financed by the European Union

EUSBSR EU STRATEGY FOR THE BALTIC SEA REGION SEED MONEY FACILITY

LIST OF ABBREVIATIONS

AC	Alternating current
ACER	Agency for the Cooperation of Energy Regulators
Baltic InteGrid	Integrated Baltic Offshore Wind Electricity Grid Development
BEMIP	Baltic Energy Market Interconnection Plan
CGS	Combined Grid Solution
CL	Construction Law
DC	Direct current
DSU	Decision on environmental conditions
DTU	Technical University of Denmark
EASS	Energy Agency for Southeast Sweden
EEPR	European Energy Programme for Recovery
EEZ	Exclusive economic zone
EIA	Environmental Impact Assessment
ENTSO-E	European Network of Transmission System Operators for Electricity
ENTSO-G	European Network of Transmission System Operators for Gas
ETS	Emissions trading scheme
EWEA	European Wind Energy Association
FNEZ	Foundation for Sustainable Energy
GHG	Greenhouse gas
GW	Gigawatt
GWh	Gigawatt hour
HLG	High Level Group
HVAC	High-voltage alternating current
HVDC	High-voltage direct current
IEE	Intelligent Energy Europe
kV	Kilovolts
kWh	Kilowatt hour
MEPs	Members of the European Parliament
MoU	Memorandum of Understanding
MSP	Marine Spatial Planning
MW	Megawatt
MWh	Megawatt hour
NSCOGI	North Seas Countries' Offshore Grid initiative

NTC	Net Transmission Capacity
NWE	North-Western Europe
O-GDP	Offshore Grid Development Plan
OWE	Offshore wind energy
OWF	Offshore wind farm
PSE	Polskie Sieci Elektroenergetyczne
RB	Rostock Business and Technology Development
RES	Renewable energy sources
SEA	Strategic Environmental Assessment
SOW	German Offshore Wind Energy Foundation
TPA	Third Party Access
TSO	Transmission system operator
TWh	Terawatt hour
TYNDP	Ten Year Network Development Plan
UOM	Act on Marine Areas of the Republic of Poland and Maritime Administration
URE	Energy Regulatory Office
VSC	Voltage source converter

EXECUTIVE SUMMARY

The State of Play Report was prepared as part of the Seed Money Facility project **"Integrated Baltic Offshore Wind Electricity Grid Development (Baltic InteGrid)"**. The aim of this initiative is to develop a full scale project (main project) proposal which will be submitted to one of the EU funding programs. Goal of such project will be to prepare a feasibility study for a Baltic offshore grid integrated with offshore wind farm (OWF) projects.

European Context

- According to the European Wind Energy Association's (EWEA) statistics[1] a total of 2,080 wind turbines were operating in 69 OWFs in 11 countries across Europe at the end of 2014. Their total capacity amounts to 6562 MW. They are capable of producing 24 TWh of electricity in a normal wind year, which is enough to cover 0.7% of the EU's total electricity consumption. The UK is the leader in terms of installed capacity in OWE in Europe, with a 56% share representing 3.6 GW, while Denmark is second with 1.3 GW. The EWEA expects the total installed capacity in OWE to reach 40 GW by 2020 and 150 GW by 2030.
- OWFs of a total of about 1.3 GW installed capacity are currently in operation in the partner countries in the Baltic Sea[2]. Based on an analysis of investor plans and scenarios of TSOs it can be estimated that in a low scenario a further 4.9 GW of installed capacity in OWFs will be built by 2030, while in a high scenario an additional 12.2 GW will operate. **Baltic Sea may become the next offshore development region** following the maturing of rising markets such as Poland, Estonia, Lithuania and initial filling of the North Sea and Irish Sea markets. **There is an immense potential for industry development and job creation within the offshore wind energy industry**.
- The European Union has set out an ambitious goal for increasing the share of renewables in the generation mix of Member States by 20% by 2020. Estimates of the market potential of offshore wind energy (OWE) suggest that this technology will play an increasingly important role in fulfilling this goal. **The development of an offshore grid, which would increase the interconnectivity of electricity markets of EU member states and facilitate the development of OWE, is strongly supported by the EU policy and is in line with the main EU priorities in energy policy, namely the sustainability, competitiveness and security of energy supply.** EU also recognizes the need to further develop Europe's electricity grid to reach the goal agreed on at the **Presidency summit in Barcelona in March 2002 for interconnectivity equivalent to 10% or beyond of Member State electricity generation capacity.** This means that export-import capabilities of Member States should be at least 10% of their power generation. Additional transnational oversea connections will improve power exchange capabilities.

  There is, however, still uncertainty regarding the post-2020 goals for the share of renewable energy sources (RES) and CO_2 emissions. Current propositions suggest 27% EU goal for the share of RES in energy consumption (non-country specific) and 40% for CO_2 emission reduction by 2030 but the issues is still being discussed. Nevertheless, it is certain that the Emission Trading Scheme and the cost of CO_2 emissions will play a significant role in the RES and as a result in grid development.
- One of the key goals of the EU is creation of a single market for electricity which is to be achieved through the process of market coupling. The role of infrastructure development prioritized by the EU is to increase transnational electricity exchange, integrate national

[1] EWEA Januaru 2014. "The European offshore wind industry - key trends and statistics 2013".
[2] Based on information from the partners of the Baltic InteGrid project.

markets into an EU single market and facilitate the integration of RES into the electricity system. The latter is especially important since more transnational connections mean better balancing capabilities of unreliable renewable energy. Excess energy can be transmitted to higher load areas. In this sense better **interconnectivity in the Baltic region may potentially enable the balancing of offshore wind power generation. What is more, the energy storage capabilities resulting from high share of hydro energy and hydro reservoirs in the Nordic countries could be used to further increase intake of the wind energy in the BSR provided there is sufficient transmission infrastructure.**

- The benefits from well integrated electricity transmission infrastructure can be immense however a strong need for more international cooperation is needed to better use the potential synergies. For example there is a need to increase interconnections between Northern and Southern Europe in order to allow excess renewable energy to be transmitted to higher demand areas. One of the steps to guarantee better coordination is a fact that Transmission system operators (TSOs) have to take into consideration the regional impact of their planned investments.
- Regarding future of European electricity grid development planning the **Ten Year Network Development Plan (TYNDP) is the most important document. In the draft TYNDP 2014 new project candidates where presented which are in line with the Baltic InteGrid project e.g. the DKE-PL interconnection between Bjæverskov (Denmark) and Dunowo (Poland).** The authors of the document acknowledge that a shift from thermal to renewables and a shift from coal to gas will drive the development of grid development.
- Development of OWE and grid infrastructure will require a well functioning supply chain including e.g. cable and turbine manufacturers, transformation stations providers, cable laying and OWF installation vessels etc. An analysis of the supply chain has demonstrated that there are bottlenecks, such as the potential shortage of cable-laying vessels and copper as an important component of cables in the case of subsea cables. Some shortages in the supply of vessels for the construction of wind turbines may occur as well if the shipowners fail to or insufficiently respond to the rising demand. Supply chain shortages may become an important factor hindering or postponing the development of OWE and connection infrastructure therefore requires an in-depth analysis.
- Research and development actions can play an important role in grid development. Apart from technology, issues regarding **integration and balancing of OWE** are an important topic with regard to research and development efforts.

Regional context

- **On a regional level, not all countries prioritize the development of OWE. In Germany and Denmark specific solutions have been implemented**, such as a support scheme with provisions dedicated specifically for this technology. **On the other hand Poland and Sweden have chosen support schemes which make all projects compete for the support on the basis of the offered price, regardless of the technologies used.** The Polish and Swedish policy documents do not specifically provide goals in terms of installed capacity, however, they do contain certain forecasts in this regard.
- Some changes can be expected in Sweden where after the parliament election in September 2014 a new government was formed. In the government declaration they announced an increased support for renewable energy and an investigation to propose a dedicated support system for offshore wind energy.

- Overall, the plans of partner countries envision a total of 9.8 GW of installed capacity in 2020, an additional 7.7 GW compared to today's state of play.
- The TSOs in partner countries all acknowledge the need to adapt the transmission grid to growing shares of wind power. **All partner states plan to increase cross-border exchange capacities.** An increase of capacity or new infrastructure is being considered between German and Poland, as well as between Denmark and Sweden.
- Although interconnections are in place, they are not always able to provide sufficient transmission capacity especially with member states which joined the EU in 2004. All countries have set out goals with the aim of expanding this capacity.
- The development of maritime spatial management plans has been identified as an important measure facilitating the development of an offshore grid and OWFs through creating stable and transparent investment conditions. At present only Germany has developed a full maritime spatial management plan. In Poland and Denmark various authorities handle issues regarding specific uses of sea areas. Poland, Sweden and Denmark have taken steps in order to develop maritime spatial plans, and consultations regarding spatial maritime planning have taken place on a regional level. Development of maritime spatial plans will help determine the best locations for OWFs and their connections, however, it is crucial to include the concept of the Baltic offshore grid at the very earliest stage to identify the key constraints and conflicts.
- The table in annex 1 lists market, legal, infrastructural, spatial, environmental and technological barriers in development of OWE and the offshore transmission grid which were identified during writing of this report. The most important barriers are:
  - In terms of market conditions, the high costs of the technology, as well as problems in the supply chain and with sources of funding were commonly identified.
  - Difficulties in legal proceedings are considered a barrier in some, but not all states. The lack of specific targets regarding OWE development in strategic policy and the lack of technology-specific RES support schemes constitutes a barrier in Poland and Sweden.
  - Grid extension is needed in order to facilitate the connection of OWFs to the grid, which is also considered an important barrier to development.
  - Issues with spatial management of maritime issues remain a problem in some states, and it is considered that a maritime spatial plan integrating OWFs and offshore transmission infrastructure would be a facilitating measure.

  Please note that the list is not full and requires further analysis.
- **Within the study a list of crucial stakeholders was produced as well as a list of similar projects. Regarding the latter there is a number of finished or ongoing projects that deal with grid development issues.** They mainly target the North Sea, however, can prove very useful for the Baltic Sea. The projects/initiatives that could directly benefit the Baltic InteGrid initiative are: OffshoreGrid and the follow up project NorthSeaGrid; Kriegers Flak project, NSCOGI initiative. Without a doubt **there is a very high potential to build on the experience gained in other EU projects and thus leap frog certain obstacles.**

INTRODUCTION

The State of Play Report was prepared as part of the Seed Money Facility project "Integrated Baltic Offshore Wind Electricity Grid Development (Baltic InteGrid)". The aim of this initiative is to develop a full scale project (main project) proposal which will be submitted to one of the EU funding programs. Goal of such project will be to prepare a feasibility study for a Baltic offshore grid integrated with offshore wind farm (OWF) projects.

Offshore wind energy (OWE) development is most dynamically developing energy sector in Europe. This has led to challenges with grid access for OWFs due to infrastructural limitations of the transmission systems, problems with balancing of the fluctuating energy sources, high connection costs (long distances, lack of synergy between projects), long lead times on high voltage cables, legal constraints, ownership issues etc. Offshore wind energy is still less developed in the Baltic Sea than in the North Sea, although significant potential exists. To realize this potential however, the aforementioned challenges have to be dealt with. This report aims to present the state of play of the development of OWE in partner countries, to identify barriers to this development and set out key areas of focus for developing potential solutions as part of the main project.

The project consortium is made up of the following organizations: Foundation for Sustainable Energy (FNEZ), Rostock Business and Technology Development (RB), German Offshore Wind Energy Foundation (SOW), Energy Agency for Southeast Sweden (EASS), Technical University of Denmark (DTU). Each of the partners provided input on the situati-on in their own country, while the Rostock Business and Technology Development provided an analysis of the supply chain and the Technical University of Denmark prepared input on the current state of research and development in the field of offshore wind energy and offshore grids.

The goal of the main project will be to improve Offshore Wind Energy (OWE) grid access and to facilitate formation of a Baltic offshore grid integrated with offshore wind energy.

Structure of the report

The report is divided into two main chapters. The first one deals with the European context of OWE and offshore grid development, while the second one looks at the regional context, through analyzing the situation in Poland, Denmark, Germany and Sweden. Both have similar structures, with sections devoted to policy, infrastructure, market and spatial issues. Additional information is provided on the current state of research and development in the field of OWE and offshore grids, relevant stakeholders and similar EU funded projects.

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1. European context

1.1. Policy

1.1.1. Goals in terms of climate policy and renewable energy development

In March 2007 the leaders of the member states of the European Union set targets in terms of climate policy and renewable energy development, committing the block to a low-carbon, energy efficient economy. In 2008 the 2020 energy and climate package was presented by the commission and adopted by the European Council and Parliament. The targets, which are known as "20-20-20 targets" include:

- reducing carbon emission by 20%,
- increasing the share of RES by 20%,
- increasing energy efficiency by 20%.

The EU also offered to increase its emissions reduction to 30% by 2020 if other major economies in the developed and developing worlds commit to undertake their fair share of a global emissions reduction effort.

The climate and energy package comprises four pieces of complementary legislation which are intended to deliver on the 20-20-20 targets:

An EU Emissions Trading Scheme

The EU emissions trading scheme (ETS) is an international system for trading greenhouse gas emission allowances. A 'cap', or limit, is set on the total amount of certain greenhouse gases that can be emitted by the factories, power plants and other installations in the system. The cap is reduced over time so that total emissions fall. Within the cap, companies receive or buy emission allowances which they can trade with one another as needed. The limit on the total number of allowances available ensures that they have a value.

National targets for non-ETS emissions

Those targets cover the reduction of greenhouse gas emissions in the sectors not covered by the ETS scheme such as housing, agriculture, waste and transport.

National renewable energy targets

Member States have taken on binding national targets for raising the share of renewable energy in their energy consumption by 2020. These targets, which reflect Member States' different starting points and potential for increasing renewables production, range from 10% in Malta to 49% in Sweden.

The national targets will enable the EU as a whole to reach its 20% renewable energy target for 2020 - more than double the 2010 level of 9.8% - as well as a 10% share of renewable energy in the transport sector. The targets will also help to cut greenhouse gas emissions and reduce the EU's dependence on imported energy.

Carbon capture and storage

The fourth element of the climate and energy package is a directive creating a legal framework for the environmentally safe use of carbon capture and storage technologies. Carbon capture and storage involves capturing the carbon dioxide emitted by industrial processes and storing it in underground geological formations where it does not contribute to global warming.

POST-2020 TARGETS

As the key driver of current European renewable energy legal framework, binding targets – expires in 2020, an important debate has begun in the EU on developing further policy guidelines and targets. The European Commission took the first step towards developing a 2030 framework for EU climate change and energy policies, through publishing a green paper discussing this issue. The paper recalls that long-term EU concepts, such as the Energy Roadmap 2050 and the Roadmap for moving to a competitive low carbon economy in 2050 were developed in line with the objective of reducing greenhouse gas (GHG) emissions by 80 to 95% by 2050 compared to 1990 levels, consistent with the internationally agreed target to limit atmospheric warming to below 2 degrees Celsius. The Roadmap for moving to a competitive low carbon economy in 2050 states that GHG emissions would need to be reduced by 40% in the EU to be on track to reach the 2050 target mentioned above. The Energy Roadmap 2050 indicates a share of around 30% for RES in 2030 in order to achieve long term goals.

Importantly, the green paper also reiterated the obligation of Members States to ensure a level of electricity interconnections equivalent to or beyond 10% of their installed production capacity, that was agreed on in 2002 as part of the conclusions of the Presidency summit in Barcelona in March 2002[3].

On 22nd of January 2014 the European Commission presented its proposal for new targets, including a 40% cut of GHG emissions and a 27% share of RES in the EU energy mix. The post-2020 goals will be discussed during the EU summit in October 2014 r.

The European Parliament has also voiced its opinion on the issue. The Members of the European Parliament (MEPs) called for a binding 40% cut in CO2 emissions from 1990 levels, a 40% target for energy efficiency, and a 30% renewable energy consumption target by 2030**.**

Before the EU summit in March 2014 thirteen member states (Belgium, Denmark, Estonia, Finland, France, Germany, Italy, the Netherlands, Portugal, Slovenia, Spain, Sweden and the UK) called on all European leaders to agree on a 40% greenhouse gas emission reduction target and a binding EU-level 27% renewables target. Others argue that binding targets should be established only after the 2015 Paris global summit on climate.

1.1.2. Strategy 2020

The EU's Strategy 2020 is a comprehensive development strategy for the block, adopted by the European Commission in 2010. A number of sector strategies were adopted as well, with the Energy 2020 Strategy for competitive, sustainable and secure energy among them.

The main document aims to develop a strategy that will contribute to growth, which will support employment, productivity and social cohesion in Europe. It contains a number of framework priorities with regard to the energy market and renewable energy in particular. The challenge of climate change is addressed in emphasizing the sustainability of future growth, and the need to achieve the 20-20-20 targets is reiterated.

Additionally, a long term commitment is made to a path leading to the decarbonisation of industrialized economies of 80 to 95% by 2050.

The flagship initiative for a resource efficient Europe was also established, with the aim of providing a long-term framework for actions in many policy areas, supporting policy agendas for climate change, energy, transport, industry, raw materials, and others. This is to increase certainty for investment and innovation and to ensure that all relevant policies factor in resource efficiency in a balanced manner.

[3] COM(2014) 15 final "A policy framework for climate and energy in the period from 2020 to 2030", 2014.

The Energy 2020 Strategy for competitive, sustainable and secure energy looks into the measures needed for achieving a sustainable development path in terms of energy supply. **The three central goals of EU energy policy are competitiveness, sustainability and security of supply.** This translates into the aim of ensuring uninterrupted physical availability of energy products and services on the market, at a price which is affordable for all consumers and does not lower the competitiveness of the EU economy, while contributing to EU social and climate goals.

The main issues, guidelines and goals touched on in the Strategy relevant to the issues dealt with by the Baltic InteGrid project are:

The internal market is still fragmented, and its integration is needed to facilitate the development of renewable energy sources.

Networks need to be adapted to generation in RES. Europe lacks grid infrastructure which allows RES to develop and compete on an equal basis with traditional sources of generation. Large scale wind parks in the North need corresponding power lines capable of transmitting this power to the areas of high consumption. Therefore, the Commission will prioritize infrastructure, which will ensure the integration of large-scale production of renewables into the energy market.

- The strategy must advance the long-term goal of RES becoming competitive with conventional generation.
- Convergence or harmonization between national support schemes for RES is needed, as the market for renewables moves from a local to a cross-border supply.
- The strategy advocates the use of more technology-specific support for RES.
- Efforts need to be made to upgrade energy infrastructure particularly in Member States that joined as of 2004.
- The EU needs to lead in innovation with regard to renewable technologies.

1.1.3. EC Communication: Renewable energy: a major player in the European energy market

In its 2012 communication to the European Parliament, the Committee of Regions and European Social and Economic Committee the European Commission reflects on the current state of integration of RES into the European energy market and address the need for development of post-2020 policy guidelines.

The Communication reminds that the cost of the installation itself is not the only driver of project costs. Complicated authorisation procedures, the lack of one-stop-shops, the creation of registration procedures, planning processes that may take months or years and fear of retroactive changes to support schemes, increase project risk, undermines competetiveness and raise project costs and for RES investors. Simple administrative regimes, stable and reliable support schemes and easier access to capital (for example through public supports schemes) will contribute to the competitiveness of renewable energy.

Although RES technologies are becoming cost-competitive, some form of R&D and other financial or administrative support may continue to be needed for newer, less mature technologies.

A new important challenge is arising as the role of RES in the European energy market grows: diverging national support schemes, based on differing incentives may create barriers to entry and prevent market operators from deploying cross-border business models, possibly hindering business development. The Commission plans to prepare guidance on best practice and experience gained in these matters and, if needed, on support scheme reform, to help ensure greater consistency in national approaches and avoid fragmentation of the internal market.

Upgrades to transmission infrastructure are required, particularly in areas where "loop flows" are causing concerns. Infrastructure development is urgent and critical for the success of the single market and for the integration of renewable energy.

1.1.4. Baltic Sea Strategy

The latest version of the European Union's Strategy for the Baltic Sea was published in 2012. It focuses on three priority aims: **to save the sea, to connect the region and to increase prosperity**. The need for increased interconnectivity within the region, both in terms of transport and energy markets is mentioned in the strategy, and the importance of the implementation of Baltic Energy Market Interconnection Plan is stressed. The Strategy also calls for an "increased cooperation in joint cross border management and infrastructure planning and implementation, including across marine areas."

The Action Plan for the EU Strategy for the Baltic region looks into the measures that need to be taken to implement these goals. The sub-objective of "reliable energy markets" is outlined. The main concern here is the isolation of the Baltic States from the EU energy market, however, the need to increase the use of RES is also mentioned. Importantly, the **Plan explicitly refers to the need for offshore grid development**, stating that the "d*emonstration of coordinated offshore wind farm connection solutions and other options to increase the use of renewable energy, monitored by EUSBSR, would facilitate the work in this area*". The Krieger's Flak project is mentioned as an example in this regard.

1.1.5. Conclusions

1. Priorities of the EU strategy in terms of energy are:

    a) security of supply of energy,
    b) increasing competitiveness of the European economy,
    c) building low-emission economy.

    Those goals have been included in the draft EU strategy presented by Herman Van Rompuy and adopted by the EU Council during the session on 26/27 of June. According to the strategy our energy and climate policies for the upcoming 5 years must focus on:

    a) affordable energy among others by: completing integrated energy market, stimulating research, development and the industrial European base in the energy field,

    b) secure energy for all countries among others by: **speeding up the diversification of energy supply including renewable energy as a means of reduce energy dependency, developing the necessary infrastructure such as interconnections,**

    c) green energy among other by setting ambitious 2030 targets that are fully in line with agreed EU objective for 2050 which is 80-95% GHG reduction. (Current proposition 27% RES EU-wide and 40% GHG reduction).

2. **Deployment of OWE and increasing interconnectivity of EU Member States is in line with the following EU strategies and documents**: Energy 2020 Strategy, EC Communication: Renewable energy: a major player in the European energy market, Baltic Sea Strategy.

3. There is still uncertainty regarding the post-2020 goals for RES and GHG emissions. It is however certain that the Emission Trading Scheme and the cost of tCO_2 will play a significant role in the RES and as a result in grid development.

1.2. Infrastructure

Network development plans on the European level have been developed by the European Network of Transmission System Operators for Electricity (ENTSO-E) and by the European Commission. For the purposes of this report the following documents have been analyzed in this regard: **The Ten Year Network Development Plan (TYNDP)** and **The 2012 Regional Investment Plan for the Baltic Sea** which is part of the TYNDP and the **Baltic Energy Market Interconnection Plan**, developed by the European Commission.

1.2.1. Ten year network development plan

The Ten Year Network Development Plan is developed by ENTSO-E biannually and is the key document regarding grid development in Europe. It is designed to increase information and transparency regarding the investments in electricity transmission systems which are required on a pan-European basis and to support decision-making processes at regional and European level. Additionally, six regional groups were created, that work on plans for individual regions. Thus, a Regional Investment Plan for the Baltic Sea has also been developed by the regional group that comprises of representatives of Norway, Sweden, Finland, Poland, Germany, Denmark and the Baltic States.

The 2012 Regional Investment Plan for the Baltic Sea foresees that the main drivers for system evolution in the region will be the preservation of security of supply, increased market integration and connection of renewable and conventional generation. After analyzing possible development scenarios of energy markets in the region, the group has reached the conclusion, that a surplus of energy generation will appear in the Nordic countries within the timeframe of the Plan. Increased interconnection capacity will be needed to drain this surplus and transmit the generated electricity to Continental Europe. The large hydro reservoirs in the North can be utilized for balancing wind and solar generation in continental Europe and to deal with demand fluctuations. On the other hand, if the interconnection capacity is not increased, investment in RES will be hampered and EU targets in this regard might not be achieved.

The figure below depicts the planned investments, as presented in the Plan.

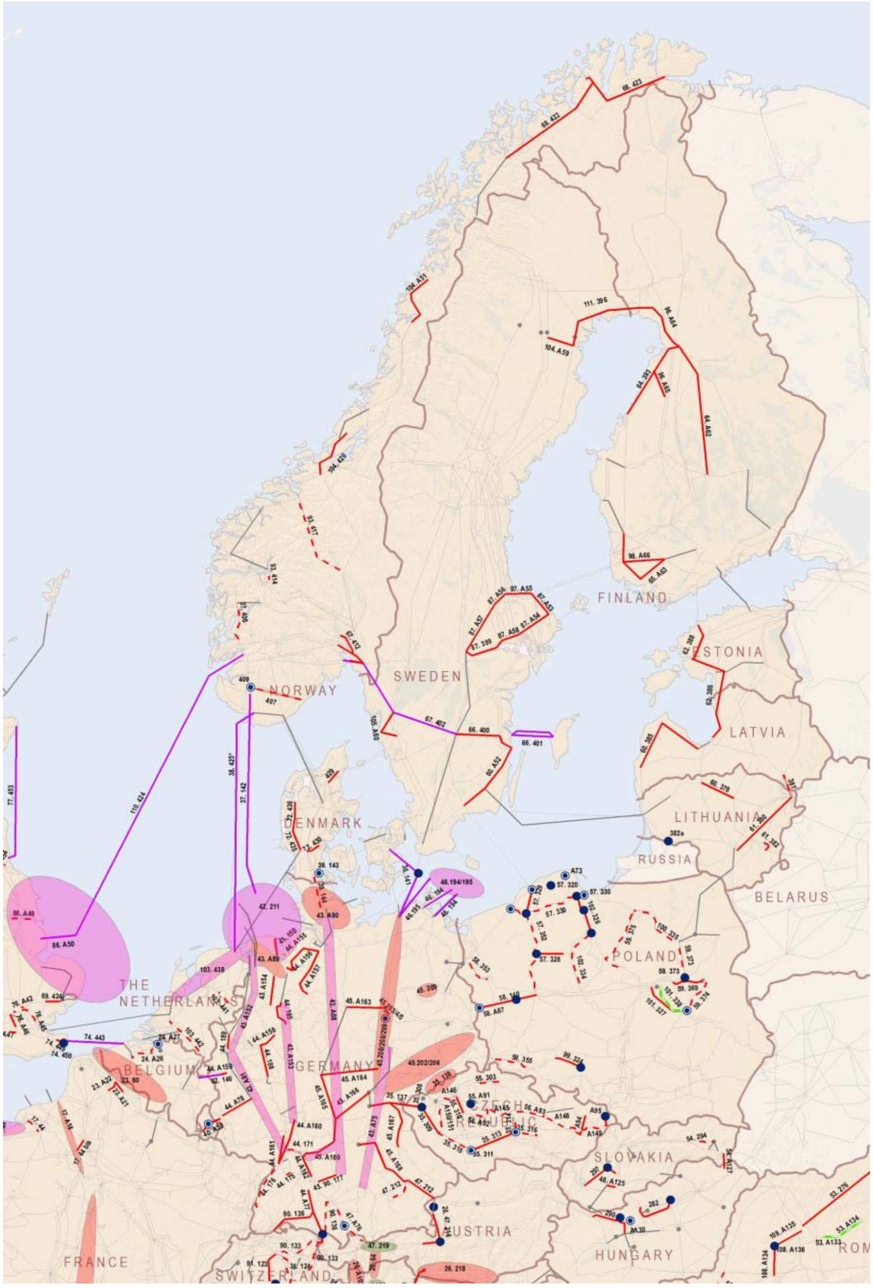

Figure 1. **TYNDP long-term projects in the Baltic Sea Area**

Currently a new version of TYNDP (2014) is under preparation. A draft of TYNPD has undergone public consultation in September 2014. Apart from the reinforced Cost Benefit Analysis of projects the draft 2014 Regional Investment Plan for the Baltic Sea also introduces 4 scenarios of grid development in the region until 2030: Slow Progress, Money Rules, Green Transition and Green Revolution.

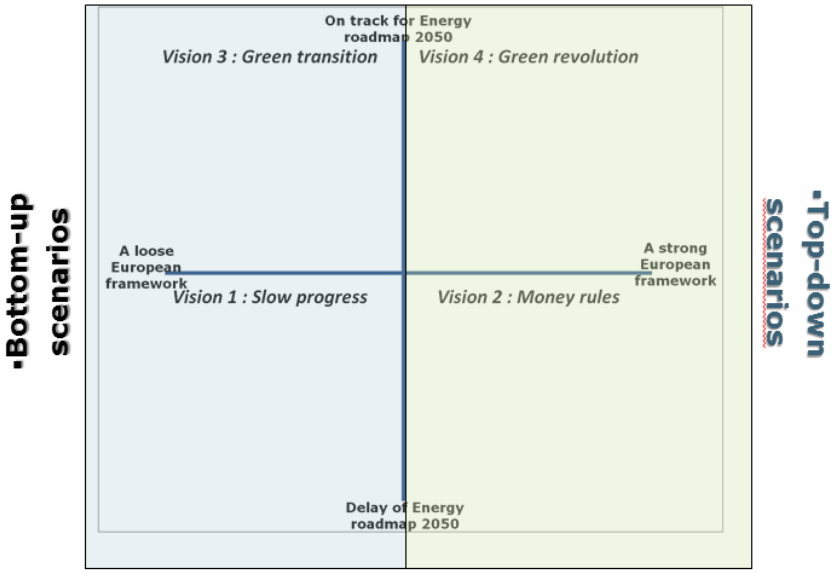

Figure 2. 4 Visions presented in the 2014 TYNDP

The 2014 Plan introduces also several project candidates which are very interesting in terms of the Baltic InteGrid projects:

- DKW - SE3 between Denmark- West and Sweden-3, called ContiScan-3,
- DKE-PL interconnection between Bjæverskov (Denmark) and Dunowo (Poland),
- Great Belt II between Denmark-West (DKW) and Denmark-East (DKE),
- Estonia-Latvia 3rd IC between Estonia and Latvia – which is a precondition for construction of off-shore wind parks in Estonia and Latvia.

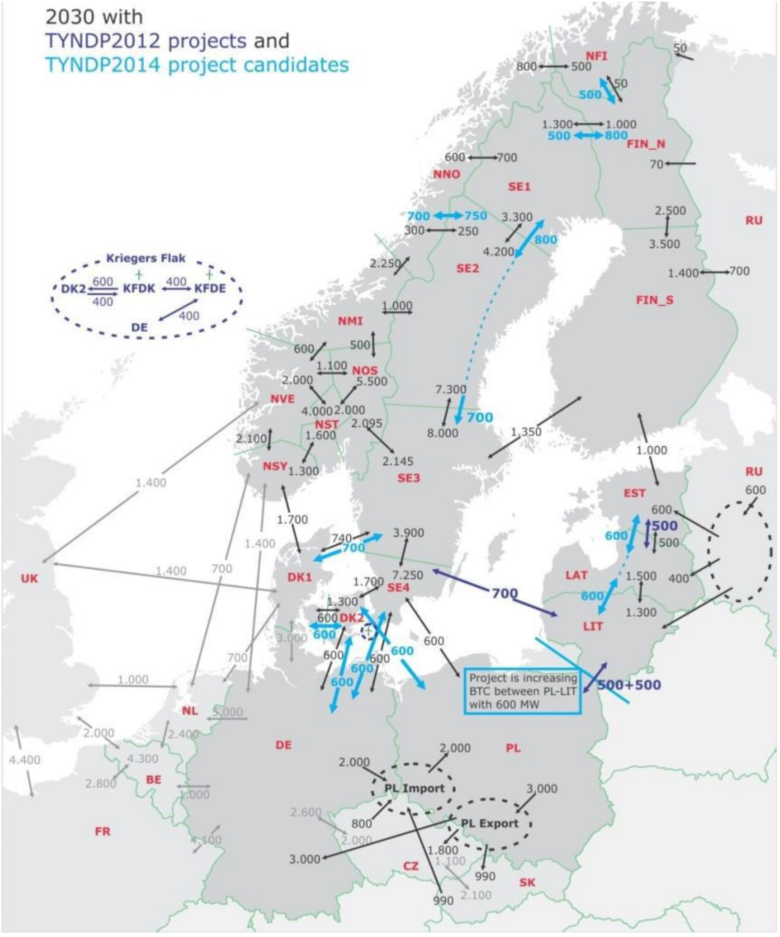

Figure 3. Map presenting investment projects listed in TYNDP 2014

As summarized in the Plan, a more flexible power system is required due to two main reasons:

- a shift from thermal to renewables,
- a shift from coal to gas.

In the long-term, integration of new renewable generation and new or upgraded nuclear power plants are the main drivers of system evolution in the Baltic Sea region. Lack of grid capacity would most probably lead to lower investments in RES, and hence not achieving RES targets. The high power flows between the Nordic area and Continental Europe will also create additional motivation for reinforcements within the Continental European grid.

1.2.2. Baltic Energy Market Interconnection Plan (BEMIP)

In October 2008 European Commission President Barroso, following the agreement of the Member States of the Baltic Sea Region, decided to set up a High Level Group (HLG) chaired by the Commission on Baltic Interconnections. Participating countries are Finland, Estonia, Latvia, Lithuania, Poland, Germany, Denmark, Sweden and, as an observer, Norway. The HLG delivered the Baltic Energy Market Interconnection Plan (BEMIP), a comprehensive Action Plan on energy interconnections and market improvement in the Baltic Sea Region in June 2009, with clear steps to be taken.

The Action Plan developed by the HLG aims at developing sufficient interconnections to the grids of Finland, Sweden and Poland, as well as at integrating the Baltic area with the Nordic power market. As in the case of the Baltic Sea Strategy, overcoming the isolation of the Baltic States from the market of continental Europe seems to be the priority. However, the Plan also mentions that the development of a liquid regional market of electricity would enable the balancing of large amounts of wind energy with the use of hydro generation in the Nordic countries, thus facilitating the development of RES. It emphasizes that infrastructure projects need to be supportive of the development of RES and cites the Kriegers Flack project as an "excellent example" of this approach.

The Plan also provides a specific list of investments to be made in energy infrastructure. The listed projects that envision electricity interconnections between states of Baltic InteGrid project partners include:

- the conversion of the Krajnik-Verraden double circuit 220 kV line into a 400 kV line together with the installation of phase-shifter transformers on the Krajnik-Vierraden line and the Mikułowa-Hagenwerder lines in order to reduce uncontrolled transmission of electricity (so called loop flows),
- the construction of the third link of the interconnection between Poland and Germany, the Baczyna/Plewiska – Eisehuttenstadt 400 kV line,
- Kriegers Flak combined solution.

Additionally the Plan projects the reinforcement or creation of the following links:

- Lithuania – with Sweden and Poland,
- Poland – with Ukraine, Lithuania and Slovakia,
- Norway – with Germany, Denmark and Sweden,
- Estonia – with Latvia and Finland,
- Finland – with Sweden and Estonia.

The investments foreseen in BEMIP will be implemented by 2020, therefore a new Baltic infrastructure strategy may be needed with new grid development projects prioritized.

Figure 4. Map of interconnections planned in BEMIP

1.2.3. Conclusions

1. The goals of the Baltic Energy Market Interconnection Plan (BEMIP) which was the key regional document for the Baltic region are to be realized within next several years. Therefore, new Baltic infrastructure strategy may be needed. In this respect the **Ten Year Network Development Plan (TYNDP)** which is updated biannually is the most important document

regarding future of European electricity grid development. In the TYNDP 2014 new project candidates where presented which are in line with the Baltic InteGrid project e.g. the DKE-PL interconnection between Bjæverskov (Denmark) and Dunowo (Poland). The authors of the document acknowledge that a shift from thermal to renewables and a shift from coal to gas will drive the development of grid development.

2. **Better interconnectivity in the Baltic region may potentially enable the balancing of wind power generation with the use of hydro reservoirs in the Nordic countries.**
3. **There is a strong need for more international cooperation in infrastructure planning**, example of which is a fact that TSO have to take into consideration the regional impact of planned investments.

1.3. Market

1.3.1. Market liberalization

The third energy package adopted in 2009 by the European Commission aims to set out a legislative framework for a competitive and effective single energy market. Market liberalization and competitiveness is to be achieved through rules ensuring that all market participants have free and equal access to energy infrastructure and transmission capacity on a non-discriminatory basis.

The crucial principle introduced in this regard is the **unbundling** of energy production and supply from network operation activities. Vertically integrated companies have to go through this process to ensure compliance with EU law. The structural separation of these activities allows non-discriminatory access to grids, ensuring competition between suppliers. This measure is also aimed at stimulating investment in cross-border infrastructure even when, for example, the new interconnector may limit the market share of the vertically integrated company. The unbundling principle had to be complied with by the 3rd of March 2012, although the implementation faced significant delays in many member states.

The **Third Party Access** (TPA) is another fundamental rule, deriving directly from the principle of independence of TSOs. According to it, TSOs must allocate transmission capacity on a non-discriminatory basis to all energy suppliers. Independent national regulatory bodies should be authorized to fix or approve tariffs or tariff calculation methods of TSOs to ensure that they are non-discriminatory and cost-reflective.[4]

Exemptions from the TPA and unbundling principles can be made in case of certain new investments. The conditions for granting such an exemption are specified in art. 17 of the Electricity Regulation (EC) 714/2009.

The Package also requires that National Energy Regulators be functionally independent from any private or public entity, and that they possess effective authority to enforce consumer protection provisions and impose effective, proportionate and dissuasive penalties.

Additionally, the Agency for the Cooperation of Energy Regulators (ACER) and the European Network of Transmission System Operators for Electricity and Gas (ENTSO-e and ENTSO-g) were created. The goal of ACER is to coordinate the work of national Energy Regulators at EU level, while working towards the completion of a single market for electricity and gas. ENTSO-e was created to facilitate cooperation between national TSOs. One of its core prerogatives is the creation of network development plans.

[4] Art. 36 Dyrektywy 2009/72/EC.

Finally, it has to be noted that regulation of electricity prices can function only in special circumstances and for a limited period of time. Price-regulation has been a significant barrier to market liberalization and an entry barrier for potential new market participants.

1.3.2. Target Model of the common electricity market

Taking into account the EU's clearly stated ambition to form a common electricity market a Target Model was developed in 2009 by the Project Coordination Group of the Florence Forum (European Electricity Regulatory Forum), with the participation of European Commission officials. In 2011, the European Council agreed to implement the Internal Electricity market by 2014, based on the proposed Target Model and roadmap.

The developed Target Model aims to integrate European forward, day ahead and intraday electricity markets, enabling participants to purchase energy from abroad on their home exchange, while simultaneously reserving transmission capacity. The process of integration is known as market coupling.

Market coupling allows a market participant to purchase electricity from a coupled market through a transaction on the market participants home power exchange, while simultaneously reserving transmission capacity (implicit trading). Trading possibilities are constrained only by limited transmission capacities. The implementation of continuous trading (instead of trading at fixed times during the day) will increase the flexibility for participants, allowing for short-term adjustments. This should facilitate the development of renewable energy sources such as wind energy, the productivity of which depends on weather conditions and is not easily predicted.

A **flow-based transmission capacity allocation method** is planned to be implemented. Capacity will be offered by a regional (e.g. Central European) entity instead of the national TSO, and will be the outcome of the analysis of bids made by market participants in the region and the physical flows that would result from them. In the traditional NTC (Net Transmission Capacity) method the transmission capacity is offered by the TSO upfront, before the submission of bids, based on the expected demand and grid constraints. Pilot projects will also be carried out for implementing the integration of balancing markets.

The roadmap envisioned day-ahead market coupling of individual regions, as the first phase of the implementation of the model. Subsequently, the day-ahead market coupling of those regions would occur, until all regions were coupled by 2015. In February 2014 the North-Western Europe (NWE) day-ahead price coupling was launched, which includes Belgium, Denmark, Estonia, Finland, France, Germany, Austria, Great Britain, Latvia, Lithuania, Luxemburg, Netherlands, Norway, Sweden and Poland (in the case of Poland, only through SwePol Link). The implementation of the project is a milestone in the creation of the single electricity market in the EU, as it covers around 75% of EU's electricity demand.

1.3.3. Offshore wind energy in Europe

According to the European Wind Energy Association's (EWEA) report[5] a total of 2,080 wind turbines are now operating in **69 offshore wind farms** in **11 countries** across Europe. Their **total capacity amounts to 6562 MW**. They are capable of producing 24 TWh of electricity in a normal wind year, which is enough to cover 0.7% of the EU's total electricity consumption.

The figure below demonstrates the share of individual countries in the overall capacity of OWFs in Europe as of the end of 2013. The UK is the leader in terms of installed capacity in OWE in Europe, with a 56% share representing 3.6 GW. Denmark is second with 1.3 GW of installed capacity, followed by Belgium (571 MW), Germany (520 MW), the Netherlands (247 MW) and Sweden (212 MW).

[5] EWEA January 2014. "The European offshore wind industry - key trends and statistics 2013".

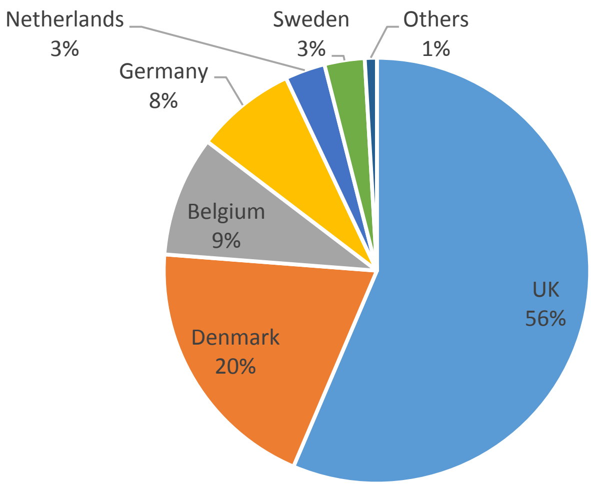

Figure 5. Cumulative share of installed capacity in OWE by country of the end of 2013[6]

Offshore wind farms of a joint capacity of 4400 MW operated in the North Sea as of the end of 2013, representing 66% of the overall capacity of OWFs in Europe. The Baltic Sea basin is second in this regard, with 17% of installed capacity (1143 MW), followed by the Atlantic Ocean with 16% (1056 MW).

Siemens is the leading offshore wind turbine supplier in Europe, with its turbines representing 60% of the current capacity of OWE in Europe. Other leading suppliers include Vestas, BARD and WinWind.

DONG is the biggest owner of offshore wind power in Europe, with 26% of the installations. Other important owners include Vattenfall, E.ON, Centrica, SSE, RWE and BARD.

The report also informs that **1567 MW of capacity was installed in Europe in 2013**, which represents a 34% increase in comparison to the previous year. The largest amount of new installations took place in the UK, followed by Denmark and Germany. 72% were located in the North Sea and 22% in the Baltic Sea. As a supplier, Siemens accounted for 69% of the market in 2013 and DONG remained the most important developer, with 48% of the total new installations.

Ten projects were under construction in 2013 and, once connected, they will provide a further 2879 MW of capacity. The majority of wind farms under construction and consented projects are located in the North Sea. EWEA has identified 22 GW of consented offshore wind farms in Europe and future plans for offshore wind farms totaling more than 133 GW.

POTENTIAL OF OFFSHORE WIND ENERGY IN EUROPE

As demonstrated above, the offshore wind industry is growing dynamically. Credible estimates of its market potential have been developed by the EWEA, as well as by the European Commission.

By 2020 EWEA expects:

- the total installed capacity in OWE to reach 40 GW,
- producing approximately 148 TWh of electricity (4-4.2% of EU electricity demand),
- annual investments in OWE to increase from 2.8 billion EUR to 104.4 billion in 2020.

By 2030 it expects:

- the total installed capacity to reach 150 GW,

[6] EWEA January 2014. "The European offshore wind industry - key trends and statistics 2013".

- producing 562 TWh of electricity (13.9% of EU electricity demand),
- annual installations of 13.7 GW and investment of 17 billion EUR in 2030.

The Association also calculated that the combined estimates of future installed capacity in OWE of the 27 Member States of the EU included in their National Renewable Energy Action Plans add up to 43.3 GW in 2020 (Croatia was not included, as it was not yet a member at the time).

On the other hand, European Commission predictions, laid out in the EU energy trends to 2030 in 2010, foresee 146 TWh of electricity production in OWE by 2020 and 276 TWh by 2030. The newest version of the document includes less precise information: total wind capacities are to increase to 205 GW in 2020, 305 GW in 2030 and 413 GW in 2050, up from 85 GW in 2010, of which around a quarter is installed offshore in 2020 and beyond.

1.3.4. Supply chain

The supply chain for offshore wind energy is a very large sector of industry. The limited supply possibilities of subsea cables itself constitutes a potential bottleneck, however other issues arise also with regard to the supply of vessels and raw materials.

The OWE supply market is specific due to the great number of large size components required for the construction of an OWF. In case of such elements as the foundations, which are not very complicated constructions in terms of technology, the crucial is the location of production facilities, therefore the network of plants producing those components is very decentralised. In case of wind turbines and the connection infrastructure the situation is different due to the high level of technological advancement. Production of those components is focused around large companies and establishing new production plants requires very positive forecasts of stable demand.

In order to systematise the OWE supply chain, it should be divided into 4 categories, which make for the major share in the execution of OWF projects. The supply in those categories is crucial for the liquidity of the execution of those projects:

- wind turbines,
- foundations,
- offshore cable infrastructure,
- vessels.

Each of those elements was described in detail, further in this chapter, with the exception of offshore cable infrastructure which is described in the next subchapter.

The suggested division shows also the share of costs of particular OWF components, including the purchase and assembly of wind turbines and towers - 45%, foundations - 24% and power installation and connection - 20%[7] (transport costs and the use of specialist vessels were included in each category).

Below we present the major plants producing the OWF components in Europe.

[7] See Diagram 19.

Figure 6. Location of major OWF components production plants[8]

Source: EWEA

Wind turbines

The supply markets of particular components of wind turbines: towers, blades, powertrain, frames and other structural elements are characterised by various conditions:

- towers are a rather simple element, therefore the production of towers is decentralised and the creation of new production plants is possible without a developed OWE market in a given country,
- the production of blades for offshore turbines requires specific construction knowledge due to considerably larger sizes than in the blades for onshore wind power plants, hence completely different construction solutions must be applied,
- powertrain - including the gear, bearings and generators, is the key element of an offshore wind turbine value chain and the production of this component is very centralised,
- structural elements such as frames, hubs, gear casings, etc. are generally available, however due to larger sizes of the offshore wind turbines the availability of these elements may drop.

Major wind turbine production plants are located in Denmark and in Germany. The UK has not been playing the major role in wind turbine supply chain so far, however, new investments and the planned development of OWF stimulates the creation of new production plants in the UK[9].

According to estimates made by EWEA, the European demand for offshore wind turbines will reach the value of 6,500 MW per year 2020 and the supply may be between 7,000 MW and 17,000 MW per year (the latter being an aggressive scenario). We can anticipate that the supply can satisfy the increasing demand for such constructions in Europe and in some parts of North America. Supply limitations, if any, will be associated mostly with the assembly plants. Limitations occurring further

[8] EWEA. 2011. Wind in our sails.
[9] EWEA. 2011. Wind in our sails.

along the supply chain and referring to particular components have already been solved and should not cause any more problems[10].

Supporting infrastructure

The major component of the supporting structures are the foundations, followed by the connecting elements, which fix the wind turbine with the foundation. Today there are several different technologies available for the construction of the foundations of offshore wind turbines. Their application depends on the depth and geological structure of the seabed in a given location. Among the basic foundation types there are: monopiles, gravity-based foundations, tripods, quatropods and jacket foundations.

The increase of demand for the supporting structures in the next decade will require a serious development of the capabilities of the foundation production plants. Minor technical barriers, short time needed for the establishment of new production plants and benefits from a local production make it easy to anticipate that there will be no downtimes during the supply of those components. This will definitely be the chance for the development of the industry in new countries oriented at establishing their own OWE sector.

The monopile foundations and gravity-based foundations have the largest share among the commissioned OWF - 74% and 16% respectively. It is related to the primary execution of projects at shallow waters, where those types of foundations are preferred. However, along with the expansion of the market and the possibilities to take the OWF further from the shore and deeper, the use of more advanced structures will increase, such as tripods or jacket foundations, which are more stable[11,12].

Mean annual demand of the European market for the supporting structures in 2020 will reach ca. 1000 items. Only for the German market there will be ca. 950 items required by 2015[13]. The major suppliers of the supporting structures for the European market are: Bladt (40% of installed structures), EEW (18%), SIF Group (18%).

Vessels

OWE sector requires various types of vessels for transportation, installation of particular components and OWF operation and maintenance. Taking into account the dynamic growth of the sector and the execution of future OWF in more demanding locations, the need for specialist vessels may become the key element of the dynamic development of the sector.

Waiting time for vessels (from the moment of placing an order to the delivery date) was in 2011 between 24 and 36 months, depending on the type of vessel.

Different vessels are used depending on the stage of the project (project development, construction, exploitation and decommissioning).

According to the estimations made by EWEA, the supply of installation vessels will seriously exceed the demand in 2015, although there may be situations in case of specialist vessels (*i.e.* for laying cables) where some problems with the supply may occur. After 2015, due to the rapid increase of demand, some shortages in the supply of vessels may occur if the shipowners fail to or insufficiently respond to the demand. It may be necessary to use the resources of the oil & gas sector.

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[10] Ibid.

[11] EWEA. 2012. The European offshore wind industry - key trends and statistics 2012.

[12] EWEA. 2011. Wind in our sails.

[13] Presentation by POWES. 2013. Morska energetyka kołem zamachowym rozwoju przemysłu i regionów nadmorskich (*Offshore energy as the driving force behind the development of coastal industry and regions*).

Offshore cable infrastructure

Like the whole cable market the offshore cable market is split between multiple international companies. The market shares of the main companies and their profiles are presented below:

Table 1. Market shares of main companies

Company name	Market share
Prysmian (Italy)	39%
Nexans (France)	17%
ABB (Sweden)	17%
NKK (Denmark)	17%
Other	10%

Prysmian was founded in 1879 as a Pirelli subsidiary and is independent since 2005 as Prysmian Cables and Systems. Its revenue in 2013 was 7.3 billion EUR. It employs 19 thousand employees in 50 countries and 91 plants. The volume of current contracts in the undersea cable secotr is 3.6 billion EUR. Three factories for sub-marine cables: Pikkala (Finland), Drammen (Norway) and Arco Felice (Italy).

Nexans was founded 1897 as Société Francaise des Câbles and renamed Nexans in 2000. It's revenue 2013 was 6,7 Billion Euro and it employs 26.000 employees in 40 countries. The sales in the submarine high voltage cable sector were up by 13% in 2012 and the companies' order book is currently running at 2 years worth of sales. Its sub-marine cable factories are located in Hannover, Rio de Janeiro(Brazil), Chiba (Japan), Halden (Norway).

NKT Cables was founded 1891 as Nordisk Elektrisk Ledningstraad og and renamed NKT Cables in 2002. Its revenue 2013: 2,119 Billion Euro and it employed 8.900 employees. Its sub-marince cable factory is located in Cologne.

ABB was founded 1883 as Elektriska Aktiebolaget and merged with Brown, Boveri & Cie in 1988 to form ABB. Its Revenue in 2013 was 30,828 Billion Euro and it employs 150.000 employees in 100 countries. The company has a sub-marine cable factory in Karlskrona (Sweden). In 2013 the Revenue in the power systems sector grew by 7% but new orders decreased by 25%.

General cable was incorporated in 1927 as a merger of multiple American cable plants. Its revenue in 2013 was 4,73 Billion EUR and it employed 14.600 employees in 26 countries.

LS Cable & System was founded 1962 as Korea Cable Industry and in 2005 renamed LS Cable & System. Its revenue in 2013 was 5,525 Billion EUR and it employed over 9 thousand employees in 16 countries. It entered the European market in 2013.

Possible bottlenecks and challenges

Potential shortage of ships:

- Special cable laying ships are needed to install the kilometers-long cables on the sea floor.
- Because of their specialized nature commissioning a new ship is very expensive, thus even large companies only have a small amount available. Global market leader Prysmian only owns two ships. There are just 80 cable laying ships active worldwide and some are up to 84 years old.
- The expansion intensity is increasing and if one of the ships breaks down it could lead to long and costly delays.

Potential shortage of copper:

- Because of its excellent electric conductivity copper is the most important component of the cables. But the strong fragmentation of the cable market makes the companies highly dependent on the prices at the commodity exchanges, which are very unstable.
- 50 – 55% of costs relate to copper and aluminum.
- According to analysts there is a looming copper shortage, because of increased demand from China. Copper storage reserves are reportedly down to just 100.000 tons worldwide.

Other technological and technical problems exist for cable laying companies. Increased effectiveness of offshore wind turbines and higher demands towards the capacity of newly laid cables results in high pressure to reach market capabilities, for the research and development departments of the cable companies. Even for experienced companies like Prysmian this can lead to problems. Because of technical complications, encountered while producing the cables for the "Western Link" connection between Scotland and England , the company announced a 32% reduction of the expected profit, in the first quarter of 2014.

While connecting the German Riffgat wind park to the power grid left over ammunition from the world wars was found, along the intended route. Before work could resume the ammunition had to be removed by specialists, which led to a delay in the project. There are an estimated combined 1.3 Million tons of ammunition left in the North and Baltic Sea.

An additional important factor for determining costs is the depth of the sea. Up to a depth of 500 meters it is advisable to either bury the cable under the sea floor or cover it in stones, to protect it from anchors, fishing nets and other external dangers. In deep sea areas it is sufficient to simply lay the cable on the bottom of the sea.

Repairing an undersea cable is very expensive because the cable has to be retrieved from a depth of possibly more than a kilometer while also having to install a temporary bypass to prevent a loss of power at the destination. However, the need for repairs rarely arises. Until now there have been no documented cases of an undersea cable malfunctioning because of internal faults. The few recorded cases of malfunctioning undersea cables were caused by external damage.

1.3.5. Conclusions

1. There is a strong drive towards **completing the single energy market** which would allow for energy cost reduction. Better interconnectivity of Member States is a key to building a single energy market /Current goal is equivalent to or beyond 10% of their installed production capacity/. EU Council has urged EU Commission to discuss new goals for interconnectivity during the October session.
2. Current capacity of offshore wind farms is 6,5 GW and it is still developing very dynamically especially in the North Sea (66% of installed capacity). **Baltic Sea may become a next offshore development region** following the maturing of rising markets such as Poland, Estonia, Lithuania and initial filling of the North Sea and Irish sea markets.
3. **There is a huge potential for industry development and job creation within the offshore wind energy industry**. Cable manufacturers alone employ 230 000 people world wide.
4. **Bottlenecks in the supply chain** - the bottlenecks include among others: cable laying vessels, subsea cables, shortage of copper.

1.4. Spatial context

The development of maritime spatial plans facilitates the investment process in terms of offshore wind energy, through alleviating problems with conflicts regarding the use of maritime areas for different purposes. The European Commission has been working on creating a common framework for developing Maritime Spatial Plans by the EU Member States.

1.4.1. EU directive on maritime spatial planning

In March 2013, the Commission proposed legislation to create a common framework for maritime spatial planning and integrated coastal management. While each EU country will be free to plan its own maritime activities, local, regional and national planning in shared seas will be made more compatible through a set of minimum common requirements.

The proposed directive obliges member states to establish and implement a maritime spatial plan. Those plans will aim to contribute to:

- securing the energy supply of the Union by promoting the development of marine energy sources, the development of new and renewable forms of energy, the interconnection of energy networks, and energy efficiency,
- promoting the development of maritime transport,
- fostering the sustainable development and growth of the fisheries and agriculture sector,
- ensuring the preservation, protection and improvement of the environment,
- ensuring climate resilient coastal and maritime areas.

Minimum common requirements

According to the proposed Directive, maritime and coastal spatial plans will at least:

- be mutually coordinated, provided they are not integrated,
- ensure effective trans-boundary cooperation between Member States, and between national authorities and stakeholders of the relevant sector policies,
- identify the trans-boundary effects of maritime spatial plans and integrated coastal management.

They should contain at least a mapping of maritime waters, which identifies the actual and potential spatial and temporal distribution of all relevant maritime activities. Member states will take into account at least the following activities:

- installations for the extraction of energy and the production of renewable energy,
- oil and gas extraction sites and infrastructures,
- maritime transport routes,
- fishing areas,
- sea farming sites,
- nature conservation sites.

Maritime spatial planning will have to be carried out in cooperation with other Member States across the coastal zone or marine region. States will organize the collection of the best available data and the exchange of information necessary for maritime spatial plans and integrated coastal management strategies.

1.4.2. Conclusions

1. In March 2013, the Commission proposed legislation to create a **common framework for maritime spatial planning** and integrated coastal management. The proposed directive obliges member states to establish and implement a maritime spatial plan. RES and interconnections are one of the key elements of marine spatial plans and have to be considered from the very beginning.

1.5. Research and development

The relevant research can be divided into two main areas:

- Electrical design and control of offshore grids and wind power plants,
- Economic impact and market integration of offshore grids and wind power plants.

1.5.1. Electrical design and control

The electrical design and control includes the entire chain from the offshore transmission grid, through the wind power plant collection grid to the wind turbines. This design is affected by the trend towards very large wind turbines and wind power plants (i.e. wind farms) offshore. The electrical design is also affected by the high priority of reliability due to high maintenance costs offshore. The transmission from onshore to offshore is becoming an increasingly important issue as the wind power plants are moving further away from the coastline resulting in the need for long distance offshore transmission. Also the possibility to combine offshore wind power transmission with offshore interconnectors between countries in future integrated offshore grids is new compared to onshore.

Some specific research areas are:

- Development of concepts for DC wind turbines and power collection grids to be connected directly to HVDC transmission grid. This concept has a potential for improvement of the reliability of the offshore wind power plant because the amount of power electronics in the wind plant is significantly reduced.
- The vast majority of existing and planned offshore wind power plants are using a power collection grid with 33-36 kV voltage level. Higher power collection voltage levels are economically advantageous, especially in future GW size wind power plants. A major advantage of using higher voltages is the reduction in investment costs. Another advantage is that it is possible to construct much larger arrays (Dermott, 2009) when the collection grid is based on higher voltage levels. Also, the reliability can be improved because lower short circuit levels make it possible to design the collection grid with a ring topology. Finally, there is a potential for reducing the losses, but this will depend on the final design.
- Development of concepts for control and protection of multiterminal HVDC transmission networks.
- Development of concepts for coordinated protection and control of HVDC converters and wind turbine converters.
- Development of alternative concepts for long distance offshore transmission. Special focus is on low-frequency AC transmission, which provides longer transmission distances without the need for reactive power compensation. The drawback of LFAC is that it requires larger transformers. Another alternative is hybrid AC / DC transmission networks.

1.5.2. Economic impact and market integration

Research on the economics and integration of offshore wind supports policy decision making in order to ensure sufficient investments and secure system operation. It includes the evaluation of long term technology cost development, energy system modelling and analysis as well as policy and market design.

In relation to offshore wind it is of particular importance to understand how large amounts of variable production affect the market as a whole. Energy system modelling is increasingly done over larger geographical regions with higher time resolutions, and provides insight into the resulting demand for flexibility and the impact of additional transmission capacity. Based on such results it is necessary to develop and simulate adequate policies and market designs that are able to meet those demands cost-effectively.

Some specific research areas include:

- Modelling of the variability of wind power is a research area for onshore wind power, but gets new dimensions offshore. This is mainly because massive offshore wind power is / will be concentrated in relatively small areas, which causes the total power to fluctuate more offshore compare to onshore, where the wind power is usually dispersed over larger geographical areas. Besides that, the wind conditions are usually more extreme offshore, so for instance the frequency of storms is much higher offshore.
- Studies of the need for reserves in power systems with large scale offshore wind power. It is usually assumed in power system studies that large scale wind power will increase the need for tertiary reserves, but not affect the need for primary and secondary reserves. Preliminary studies have shown that development of massive offshore wind power concentrated in relatively small area will also affect the needs for primary and secondary reserves in the power systems.
- The market price impacts of wind power have been studied mostly in a national context. Interconnected offshore wind farms require an international perspective. The regulatory regime governing market access plays an important role establishing the market value of the wind production on the one hand and the impact on the value of other assets on the other hand.
- A research area looking into determining future costs of offshore wind technology provides important inputs to energy system modelling and policy analysis. In particular the question of how much of cost digression may be attributed to experience and how much may be attributed to research has been the subject of recent activities.
- The layout of offshore grids may have substantial socio-economic consequences. Recent analysis shows that a meshed approach is likely to be the superior solution. It will require political intervention to establish, however.

1.5.3. Conclusions

1. Apart from technology, issues regarding **integration and balancing of OWE** are an important issue with regard to research and development efforts.

2. Regional context

2.1. Policy and regulation

2.1.1. Offshore wind energy and offshore infrastructure in state strategy

DENMARK

Energy Agreement

This is the main political document regarding the future Danish energy policy and thus development of offshore wind energy. It covers the official governmental targets up until 2020 within energy efficiency, renewable electricity and heating, smart grids, and transitions of the transport sector and gas sectors.

<u>OWE:</u>

- Establishment of 600 MW at Kriegers Flak is planned before 2022.
- Establishment of 400 MW at Horns Rev is planned before 2020.
- In addition, 400 MW of wind energy is to be installed at near-shore sites by 2020.
- Political negotiations are ongoing (end of 2014) with regards to add a milestone "no coal" in 2025.

Offshore Wind Action Plan

The offshore related government targets are backed by basic analyses on potential placement of offshore wind farms by the Danish Energy Agency. A first Offshore Wind Action Plan has been published 1997. The latest updated feasibility analyses have been conducted in 2007 and 2011.

<u>OWE:</u>

- The Offshore Wind Action Plan of 1997 resulted in an obligation towards the Danish electricity utilities to install offshore wind farms at five demonstration sites with a total capacity of 750 MW before 2008. By 2002 two of the parks have been erected.
- However, following the liberalisation of electricity markets the remaining obligations for three farms (corresponding to 450 MW) were cancelled . Instead a market based development was to be pursued. Thus in 2004 a tendering procedure has been initiated that is still the principle behind offshore wind development today.

Strategy Plan

Every second year in even years Energinet.dk, the Danish TSO publishes its Strategy Plan. It is prepared as a report for the Danish Ministry of Climate, Energy and Building and contains a summary of the future conditions and the system operators overall strategies. At the time of writing the latest version is the Strategy Plan 2012.

<u>OWE</u>:

- The most important development as seen in the latest plan is the general consensus in Denmark of becoming independent from fossil fuels. This is going to be achieved by largely focusing on wind energy and biomass.
- A major challenge is the integration of large shares of wind power production both onshore and offshore requiring consumption and the rest of the production to become significantly more flexible.

- In the longer term perspective it aims at a flexible system integrating all energy sectors – electricity, heating, gas and transport.
- In addition storage is considered an option.

Interconnections:

- In the short to medium term Energinet.dk will focus on maintaining security of supply by further developing international markets and interconnections.

System Plan

The System Plan is developed annually and published in December as a part of Energinet.dk's reporting to the Danish Energy Agency. At the time of writing the latest version is the System Plan 2013. The System Plan provides a more detailed outlook and status.

Interconnections:

- Capacity expansion with Germany and Sweden is under consideration.
- COBRACable: A subsea interconnection between Denmark and the Netherland could be established by the end of 2019.
- An interconnector with the UK is still in the conceptual phase.

GERMANY

Renewable Energy Sources Act:

The main concern of the 2014 Renewable Energies Law is to keep costs down without halting the expansion of renewable energies, and thus Germany's shift to a more sustainable energy supply.

OWE:

- The act introduces a support scheme for renewable energy sources, including OWE.
- A target total of 6.5 GW of installed capacity by 2020 and 15 GW by 2030 is set.

Federal trade plan for offshore

The aim of the document is to ensure coordinated and consistent spatial planning of grid infrastructure and grid topology, particularly for the grid connections of offshore wind farms in the German EEZ of the North and Baltic Sea up to the 12 nautical mile border of the territorial waters. The scope of the Federal Trade Plan for Offshore covers

- the identification of offshore wind farms suitable for collective grid connections,
- spatial routing for subsea cables required to connect offshore wind farms,
- sites for converter platforms or transformer substations,
- interconnectors,
- a description of potential cross connections between grid infrastructures and
- standardized technical rules and planning principles.

Offshore Grid Development Plan

The four transmission system operators (TSOs), 50Hertz, Amprion, TenneT and TransnetBW, have had the task of producing an annual electrical Offshore Grid Development Plan (O-GDP) for the expansion of the land-based transmission net-works in the next 10 or 20 years based on the amended

Energy Industry Act. The plan is based on the Federal Trade Plan for Offshore of the Federal Network Agency (German: Bundesnetzagentur; BNetzA).

Offshore grid:

- The O-GDP establishes the requirement for grid connection systems and determines the start and end points of grid connection systems taking into account the expected geographic distribution of the offshore wind farms and the connection capacity available at the grid connection points in the transmission network.
- Specific transmission line routes are not part of the O-GDP but will be defined in the EEZ as part of the Federal Trade Plan for Offshore by the Federal Maritime and Hydrographic Agency (German: Bundesamt für Seeschifffahrt und Hydrographie, BSH) and in coastal waters by the BNetzA in conjunction with the littoral states.
- Work on the O-GDP 2014 is in progress. The volume of offshore grid expansion needed is calculated at 1,135 km in Scenario A 2024, 1,605 km in Scenario B 2024 and up to 2,540 km in Scenario C 2024.
- The investment costs for the network measures are calculated in the O-GDP on the basis of specific cost estimations and are of a provisional nature. Depending on the scenario, the total volume of investments over the next ten years totals between 17 and 23 billion euro. This already takes into accounts investments of approximately twelve billion euro for the starting grid offshore.

OWE:

- Scenario A 2024 would be sufficient for an additional 3.7 GW installed capacity in OWF,
- Scenario B 2024 would be sufficient for an additional 5.1 GW of OWE,
- Scenario C 2024 would be sufficient for up to 7.9 GW new installed capacity in OWF.

Federal Requirements Plan

Together with the environmental report, the Network Development Plan forms the draft Federal Requirements Plan. This contains a list of the necessary projects – including start and end points for each new construction project. The federal government is presented with a draft such as this at least every three years. This starts the legislative process which concludes with the necessity of all projects being determined by law.

National Renewable Energy Action Plan

OWE:

- 25 GW offshore wind energy should be realized until 2030.
- In August 2014, a new EEG was passed. The new extension targets are limited to the targets in 2012. Thus, 6,5 GW should be installed in 2020 and 15 GW in 2030.
- From 2020 400 MW should be installed yearly (= about 2 wind farms per year).

SWEDEN

Swedish Energy Bill of 2009

This is the main document in terms of energy and climate policy in Sweden. It sets the goal for at least 50% of share of RES in the energy mix. It also mentions the establishment of offshore wind farms which would produce 10 TWh of electricity yearly. However, this cannot be seen as a goal, just an expectation on information available at that point in time. The necessary capacity will be built if the industry manages to make offshore wind energy more cost-competitive, as the Swedish supports scheme for RES does not favor any type of RES.

Offshore grid:

- The conditions for sea-based wind power connections shall receive particular attention.

OWE:

- A planning framework for wind power of 30 TWh is proposed, 20 TWh of which shall be on land and 10 TWh offshore.

Perspective Plan until 2025

This document gives an overview of planned grid development until 2025. The document concludes in a number of proposals for reinforcements that will prepare the grid for coming needs and that will secure quality of the grid.

OWE:

- The total wind energy production in the plan is assumed to be 17-20 TWh 2025. Three scenarios is presented with different distribution between land based and OWE. OWE production is 0,5 – 0,5 – 7,8 TWh in the three cases.
- There are several major projects for offshore wind power in the planning stage. These include Storgrundet southeast of Söderhamn, Big Middelgrund in Kattegatt and Trolleboda in Kalmar. At Krieger Flak planned interconnection of Danish and German offshore wind power. Southern Midsjöbankarna in the southeastern Baltic Sea is another major project.
- The document states that offshore wind energy has not yet reached breakthrough in Sweden. To allow for wind farms far out to sea, it will be necessary to introduce special financial support.

Interconnections:

- The Nordbalt project between Lithuania and Sweden is mentioned, as well as the connection between Sweden in Finland, however no details are given in case of this second link in terms of capacity, location or time frame.
- Work is planned on the link between Sweden and Denmark, but it seems it will not give increased capacity, and will just replace old cables.

POLAND

Energy Policy of Poland until 2030

Current document was developed in 2009. Work on an updated version of the Energy Policy of Poland until 2030 is currently in progress.

OWE:

- The document sets the target for a 15% share of renewable energy in electricity generation in Poland by the year 2020, however it does not set targets for individual technologies.
- Offshore wind farms are mentioned specifically by stating that "the development of wind power, both on land and at sea, is predicted" and it is necessary to create "conditions facilitating the decision-making process in terms of investments in offshore wind farms".

Interconnections:

- The document mentions the need to develop cross-border connections coordinated with extending the domestic transmission system as well as the systems in neighboring countries, which will allow to exchange at least 15% of electricity used in Poland by 2015 (which would equal approximately 23,5 TWh per year of exchange capacity), 20% by 2020 and 25% by 2030.

National Renewable Energy Action Plan

This document was issued in 2010 in order to fulfil the obligation of EU member states to create a Renewable Energy Action Plan, which would lay out the plans for the realization of their policy with regard to renewable energy sources.

OWE**:**

- An installed capacity of 500 MW in offshore wind farms is foreseen starting from year 2020, which would generate 1500 GWh of electricity (the document does not assess further development of offshore wind energy, as the estimates it includes extend only until the year 2020).

Maritime policy of Poland up to 2020

OWE:

- The project of this document, issued in 2013, lists the enhancement of national energy security as one of the nine priorities of maritime policy. The importance of the potential of wind energy and the construction of new transmission infrastructure is emphasized in this regard.
- The Policy also states that it is necessary to create "conditions facilitating construction of offshore wind farms".

Nuclear power program for Poland

Adopted by the Polish government in February 2014, it sets out detailed plans of introducing nuclear power generation in Poland.

OWE**:**

- The document is relevant in the context of OWE as it is the most up-to-date source of information on current government estimates of future energy mix including installed capacity in OWF. The Program foresees the launch of the first farm in 2022, with OWE capacity reaching approximately 2 GW by 2030.

Report on the reliability of electricity supply

Interconnections:

The report sets the following goals in terms of import/export capacity of each interconnector:

Table 2. Exchange capacity goals of interconnectors

	Import	Export
Continental ENTSO-e	3000	3000
Lithuania	1000	1000
Belarus	600	600
Ukraine	1400	1200
Sweden	600	600

Development plan for the purposes of meeting current and future energy demand in the period 2010-2025

This document, issued in 2010 by *Polskie Sieci Elektroenergetyczne* (PSE), the Polish Transmission System Operator (TSO), presents the main goals and detailed grid development plans of the operator.

OWE:

- the expansion of the station in Żarnowiec and Słupsk-Wierzbięcino is planned in order to connect planned offshore wind farms to the grid.

Interconnections:

- As a result of the implementation of the Plan, the exchange of electricity will be possible between Polish and Lithuanian electricity systems.
- PSE draws attention to the problem of so-called loop flows, which pose a threat to the stability of the Polish electricity system and limit the exchange capacity of the interconnectors with Germany, Slovakia and Czech Republic. This capacity will be enhanced through the installation of phase-shifter transformers, which will limit the so called "loop flows". This will allow for an increase of import capacity by 500 MW, and export capacity by 1500 MW.
- Subsequently the construction of a new 400 kV connection will be necessary in order to further increase import/export capacity.

2.1.2. Support scheme for offshore wind energy

The RES support schemes of Denmark, Poland, Germany and Sweden are summarized below. Information on the level of support in EUR is provided in subchapter 2.3.1.

DENMARK

Support mechanisms for renewable energies are regulated by law in the *Promotion of Renewable Energy Act*. For offshore wind energy support consists of a fixed settlement price for the produced electricity. The price is determined in a tendering process in which the bidder with the lowest price per kWh is awarded the permission to install the offshore wind farm at a predetermined site.

The wind farm owner has to sell the produced electricity to the market and the fixed price is achieved by a contract-for-difference covering the difference between the hourly spot market price and the tendered fixed price. The latest tender included a regulation that the contract-for-difference will not be paid out at negative market prices.

The duration of the support is laid out in the tender for the individual wind farm but will approx. cover 50,000 full load hours.

As an alternative the so called open-door permitting procedure exists. It is mainly relevant for near-shore projects. It cannot be applied in areas that have been reserved for offshore wind development and moreover, in contrast to the tendered parks, the export cable and onshore grid connection has to be paid for by the wind farm owner. A 21 MW park in the Great Belt between Sealand and Funen has been established on the basis of the open-door procedure, for instance.

GERMANY

Renewable energy sources (e.g. wind, water and solar energy) are privileged under the Renewable Energy Act. Grid owners are obliged to access energy suppliers producing energy exclusively by water, wind, solar, geothermal, natural gas, marsh gas or biomass and to purchase the electricity generated in such plants at certain minimum rates as provided for in § 19 Renewable Energy Act.

In the EEG the power which is being produced in offshore wind farms is entitled to fixed feed-in tariffs, i.e. the operator receives a fixed number of cents (ct) per kilowatt hour (kWh). The period is 20 years.

The EEG currently provides two different approaches of remuneration for offshore wind farms which started operation before January 1st, 2018. An OWF developer may claim the higher level of remuneration for a shorter period of time, or a lower level of remuneration for a longer amount of time.

Extension of the remuneration period is also possible, depending on the distance between the wind park and the coast and the water depth at the location.

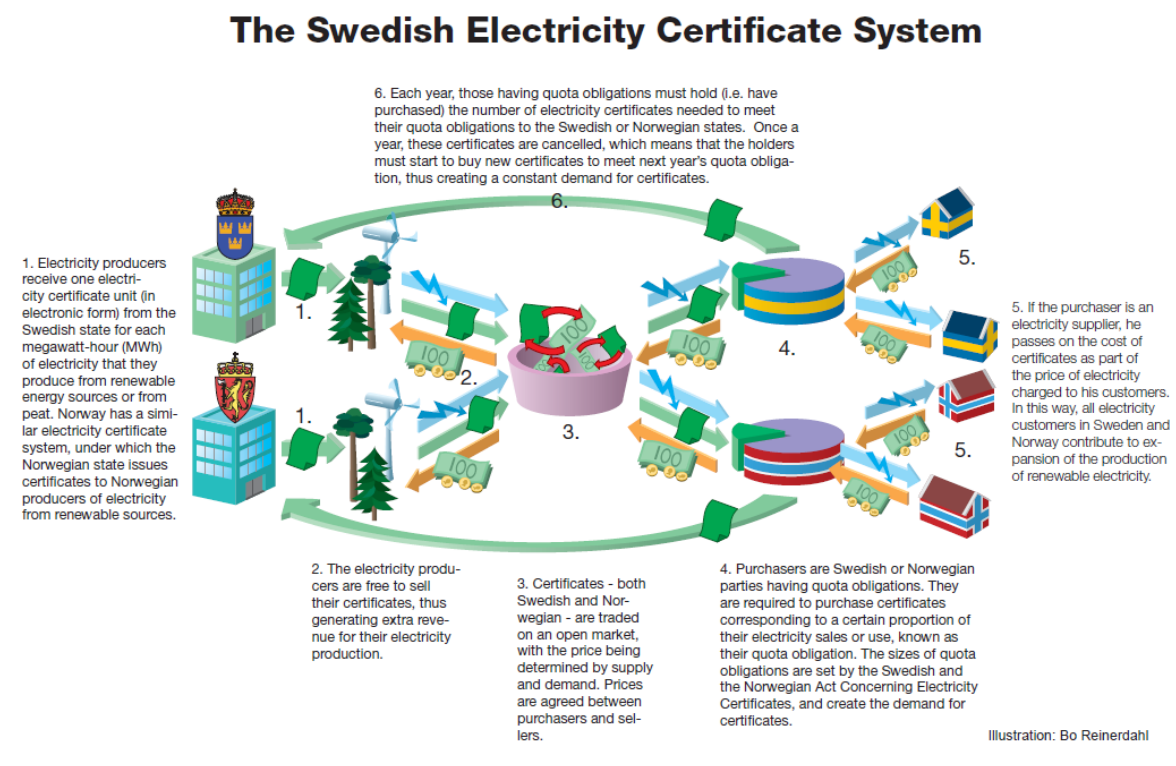
A further important principle is the priority feed-in of electricity from renewable energy sources. The operators have the claim to an immediately connection of their plant on the power grid. They have the claim to an immediately purchase of the electricity.

SWEDEN

Sweden has one support mechanism for renewable electricity independent on technology. The certificate systems give the same support per kWh to wind-, sun-, bio- and hydro-power. The target for total new RES based electricity productions is set by the parliament but the "market decides" what type RES that will be built, probably the most cost effective technology. The value of the certificates is also set depending on supply and demand on the certificate market place.

Sweden and Norway has a common certificate market since 2012 i.e. to change the system both of the countries need to express consent.

Figure 7. The Swedish Electricity Certificate System



After the election to the parliament in September 2014 Sweden has formed a new government, which declared an increased support for renewable energy and an investigation to propose a support system for offshore wind energy.

POLAND

The Polish government is working on an Act on Renewable Energy Sources which will change entirely the current support scheme for RES. The act was approved by the Council of Ministers in April and is undergo further legislative process in the parliament and the Chancellary of the President. Below is a description of the current scheme based on the green certificates system (so called quota system) and the planned tender system based on the latest project of the Act of 28th March 2014, which may yet undergo changes. Taking into account the likely date of launching the first offshore wind farm in Poland, the new system will probably be the one applicable to OWE.

Current support scheme

The current support scheme for RES in Poland is based on a system of green certificates. The scheme is neutral in terms of technology, it does not favor any specific type of RES, which results in companies investing in the cheapest RES technologies. At the end of the year every company that sells electricity to consumers is obligated to present the chairman of URE (the Energy Regulatory Office) with a number of green certificates corresponding to a certain share of its electricity generation. The share is set to a different amount every year. The producer can either generate the necessary amount of electricity in RES, purchase the green certificates from other market participants or transfer the buy-out price to the account of the National Fund for Environmental Protection and Water Management. Therefore, the first source of income for an RES producer is the payment he receives for the generated electricity, that he sells for a market price, and the second are the proceeds from selling the green certificates, which are sought by other market participants in order to fulfill the obligation imposed on them by the regulator. Apart from this the company which owns the distribution grid is obligated to purchase all electricity generated in a RES.

Planned support scheme

In order to obtain support, every new RES source starting to operate after the entry into force of the RES Act will have to compete for the support in tenders organized at least once a year by the chairman of URE, which will guarantee the successful projects a fixed price for the electricity for a period of 15 years. The system is based on a Feed-in-Premium principle meaning that investors receive the difference between the price of energy sold and the price won in tenders. The participants submit offers of generating a defined amount of electricity for a proposed price per MWh. The maximum price ("reference price") for a MWh will be set by the Minister of Economy at least 60 days before the tender. This "reference price" will be different for each technology, however all projects will then compete for the support on equal terms, with price as the main criteria. Offers exceeding the reference price will be rejected automatically. Additionally, the Council of Ministers will determine before the 31st of October of every year the maximum amount of electricity that can be produced in renewable energy sources with the efficiency less than 4000 MWh per MW per year.

Renewable energy sources which started functioning before the entry into force of the new legislation will have the possibility to choose between obtaining support through the quota system until no later than 2021 or the new tender system. Planned sources of generation are granted a period of 48 months before they are required to start producing electricity, except for:

- photovoltaic farms, for which the period is reduced to 24 months, and
- offshore wind farms, for which the period is extended to 72 months.

As a result of the auctions the supply of electricity is carried out for 15 years, but no longer than until the 31st of December 2035. For offshore wind farms this period is extended until the 31st of December 2040.

The mechanism of the support scheme described above still needs to pass through proceedings in the parliament and the Chancellary of the President. Sources within the government have indicated possible changes in favor of OWE, possibly including separate auctions in the future.

2.1.3. Conclusions

1. **Lack of uniform approach towards OWE in the Baltic region** - there are strong differences in the approach of Baltic Sea Region Member States towards offshore wind energy in terms of strategic planning and support schemes. For example in Germany the offshore grid is centrally planned through series of strategic documents whereas in Poland it is planned (currently) solely by investors. Moreover, German and Danish strategic policy documents explicitly provide targets for the installed capacity in OWE and include documents specifically dedicated to the development of OWE, while Swedish and Polish strategic policy documents do not.
2. **Cost reduction of offshore wind is a key issue in partner countries.**
3. **Lack of targets and strategy towards the development of offshore wind power in Poland and Sweden.**
4. **Lack of dedicated support mechanisms for OWE** in Poland and Sweden which hinders development of this technology due to high investment costs. Some changes may be expected in Sweden due to new formed government and their declaration to investigate the possibility of a dedicated support mechanism for offshore wind.
5. **Very high potential for experience exchange between western** Baltic Member States and eastern Baltic Member States, especially in terms of strategic planning of integrated offshore wind energy development.

2.2. Infrastructure

2.2.1. Existing offshore wind farms and connection infrastructure in the Baltic Sea

Offshore wind farms of a total of about 1.3 GW installed capacity are currently in operation in the partner countries on the Baltic Sea.

The table below presents a list of operating OWFs in the Baltic Sea.

Table 3. Operating offshore wind farms in the Baltic Sea

Name of the project	Investor	Capacity of the project (MW)	State of development	Type of transmission Voltage	Length of the export cable (km)	Cost of OWF
Denmark						
Nysted (2003)	PensionDanmark, DONG Energy, Stadtwerke Lübeck	165	in operation	HVAC, 132 kV	10.75	245
Rødsand II (2010)	E.ON, SEAS NVE	207	in operation	HVAC, 132 kV	9.2	450
Vindeby (1991)	DONG Energy	5	in operation	MVAC, 10 kV	1.3	8.8
Tunø Knob (1995)	DONG Energy	5	in operation	MVAC, 12 kV	6	12
Middelgrunden (2000)	DONG Energy, Middelgrundens Vindmøllelaug	40	in operation	MVAC, 30 kV	3.5	45

Name of the project	Investor	Capacity of the project (MW)	State of development	Type of transmission Voltage	Length of the export cable (km)	Cost of OWF
Horns Rev I (2002)	DONG Energy, Vattenfall	160	in operation	HVAC, 150 kV	21	278
Rønland (2003)	Thyborøn-Harboøre Vindmøllelaug, Harboøre Møllelaug, Vindenergi Aps	17	in operation	-	distance to shore 0.1	-
Samsø (2003)	Samsø municipality, Difko A/S	23	in operation	MVAC, 30 kV	4	35
Frederikshavn (2003)	DONG Energy	7	in operation	-	distance to shore 3	
Avedøre Holme (2009/10)	DONG Energy, Hvidovre Vindmøllelaug	11	in operation	-	distance to shore 0.4	100
Sprogø (2009)	Sund & Bælt Holding	21	in operation	MVAC, 10 kV	0.7	-
Anholt (2013)	DONG Energy, PKA, PensionDanmark	400	in operation	HVAC, 220 kV	24.5	1300
Germany						
EnBW Windpark Baltic 1	EnBW Erneuerbare Energien GmbH	48 MW	Operation since 2010	150-kV-AC-	70	200 m Euro
Sweden						
Bockstigen	n/a	2,75 MW	In operaton	n/a	3	n/a
Utrgunden I	Vattenfall	10 MW	In operaton	n/a	7	n/a
Yttre Stengrund	Vattenfall	10 MW	In operaton	n/a	4	n/a
Lillgrund	Vattenfall	110 MW	In operaton	n/a	10	n/a
Vindpark Vanern	Vindpark Vanern	30 MW	In operaton	n/a	4	n/a
Karehamn	E.ON	48 MW	In operaton	n/a	4	n/a

2.2.2. Transmission system operators

A list of transmission system operators is presented below. In the case of Poland and Denmark, one state-owned TSO is responsible for the operation of the whole grid. In Germany's case, 4 separate

TSOs, with a mixed ownership structure, are responsible for the operation different sections of the transmission grid.

Table 4. List of transmission system operators

Name	Geographical competence	Ownership
Energinet.dk	Denmark	Owned by the Danish state
TenneT GmbH	Germany – Schleswig-Holstein, Lower Saxony, Hesse, Bavaria, North Sea	Owned by the Dutch Government
50Hertz GmbH	Germany – Berlin, Brandenburg, Hamburg, Mecklenburg-Vorpommern, Saxony, Saxony-Anhalt, Thuringia, Baltic Sea.	Owned by Eurogrid GmbH, indirectly owned and managed by the Belgian TSO Elia and the Australian-based Industry Funds Managament.
Amprion GmbH	Area between Lower Saxony and the border to Switzerland and Austria	Owned by German financial investors from the insurance and pension fund industry. Minority share of RWE AG.
TransnetBW	Germany - Baden-Wurttemberg	Owned by EnBW, in which federal state Baden-Wurttemberg has a share of 46,75%
Svenska kraftnät	Sweden	Owned by the Swedish state
PSE (Polskie Sieci Elektroenergetyczne S.A.)	Poland	Owned by the Polish state

2.2.3. Cross border transmission capacity

Table 5 presents the exchange capacities of the interconnections between partner states.

It is worth noting that a major obstacle to planning cross-border trade between Poland and Germany has been the so-called **loop flows.** The uncontrolled nature of these flows limits the ability of the TSO to offer transmission capacity to market participants due to issues related to the security of the functioning of the grid. PSE and the 50Hertz have agreed on the installation of phase-shifter transformers in order to mitigate this problem. The Polish TSO claims that this will increase import capacity by 500 MW and export capacity by 1500 MW. The construction of the third line on the German-Polish border is to further increase import capacity by 1500 MW and export capacity by 500 MW.

Energinet.dk on the other hand plans to increase the capacity of the interconnection between Denmark and Germany by 1100 MW for exports to Germany and by 1400 MW for imports to Denmark by 2020, partly through the implementation of the Kriegers Flak project. The capacity of this interconnection is to be further increased by 500 MW by 2025, both for import and export.

Table 5. Exchange capacities of interconnections (in MW)

Import \ Export	PL	DE	SE	DK
PL	X	0	600	No connection
DE	900	X	no data	2380
SE	300	no data	X	2480
DK	No connection	2100	1980	X

The table below presents the exchange of electricity between partner states in the last 5 years. In most cases it is difficult to establish a pattern, as the exchange balance varies greatly depending on the year. The exception has been the exchange between Poland on the one hand, and Germany and Sweden on the other, which presents a clear pattern of Poland being the net importer in relation to both states.

Table 6. Exchange of electricity between states (in MWh)

	2009	2010	2011	2012	2013
DE → SE	1132	2355	628	295	1048
SE → DE	949	1007	2047	2907	1077
DE → DK	3615	6471	2906	1439	5772
DK → DE	6234	2702	5055	8177	3233
DE → PL	5618	5334	5138	6050	5451
PL → DE	135	167	433	173	542
PL → SE	254	494	278	128	763
SE → PL	1394	761	1514	2673	1016
DK → SE	3150	4978	2807	1629	5093
SE → DK	3838	2656	5141	9001	3134

Table 6 presents a list of cross-border connections of partner states. At present:

- 1 link exists between the Polish and Swedish grids,
- 2 links exist between the Polish and German grids, with one more currently being planned,
- 3 links exist between the Danish and Swedish grids,
- 2 links exist between the Danish and German grids.

DK-E refers to Denmark East, while DK-W refers to Denmark West.

Table 7. List of cross-border connections

Name of the interconnector	Operator of the connection	Capacity of the transmission (import/export) [MW]	State of development	Type of transmission Voltage	Length of the connection	Connection point	Cost
Interconnections of partner states in the Baltic Area							
DK-E – SE	Energinet.dk, Svenska Kraftnätt	1300/1700	In operation	HVAC, 400 kV & 132 kV	n/a	Kvistgård /Ishøj (DK)	n/a
DK-E – DE, Kontek	Energinet.dk, 50 Hertz	600	In operation	HVDC, 400 kV	n/a	Bjæverskov (DK)	n/a
DK-W – SE, Konti-Skan	Energinet.dk, Svenska Kraftnätt	680/740	In operation	HVDC, 285 kV	n/a	Vester Hassing (DK)	n/a
DK-W – DE	Energinet.dk, Tennet	1500/1780	In operation	HVAC, 400 kV & 220 kV	n/a	Kassø (DK)	n/a
DK – SE, Bornholm – Sweden	Energinet.dk, Svenska Kraftnätt	60	In operation	HVAC, 60 kV	n/a	n/a	n/a
DK-W - DK-E, Great Belt	Energinet.dk	600	In operation	HVDC, 400 kV	n/a	Fraugde (DK) Herslev (DK)	n/a
SE – DE, BalticCable	Statkraft AS	600	In operation	HVDC 450 kV	250 km	Trelleborg (SE) – Lubeck (DE)	n/a
SE – FI, Fenno-Skan 1&2	Svenska Kraftnät, Fingrid	500 + 800	In operation since 2011	HVDC 400 kV	200 km		
SE – LT, NordBalt	Svenska kraftnät and Litgrid (Lithuania)	700	Ongoing, ready end 2015	HVDC, 300 kV	400 km	Klaipėda (LT) and Nybro (SE)	EUR 552 million
PL – SE, SwePol Link (subsea cable)	PSE Operator S.A., Affärsverket Svenska Kraftnät	600	In operation	HVDC 450 kV	~250 km	Słupsk-Wierzbięcino (Poland)	n/a
PL – DE, Krajnik – Vierraden	PSE Operator S.A., 50Hertz	2 x 402	In operation	400 kV	~16 km	Krajnik (PL)	n/a

Name of the interconnector	Operator of the connection	Capacity of the transmission (import/export) [MW]	State of development	Type of transmission Voltage	Length of the connection	Connection point	Cost
PL – DE, Mikułowa – Hagenwerder	PSE Operator S.A., 50Hertz	2 x 1385	In operation	400 kV	~10 km	Mikułowa (PL)	n/a
PL – DE, GerPol Power Bridge	PSE Operator S.A., 50Hertz	3750	Conceptual phase	380 kV	-	Plewiska (PL)	n/a
PL – LT, LitPol Link	PSE Operator S.A., Lietuvos Energija	500 MW in 2015 1000 MW in 2020	In construction	400 kV	163 km	Ełk (PL)	347,5 mln EUR (2015)
Interconnections with other states							
DK-W – NO, Skagerrak 4	Energinet.dk/Statnett	700	under construction	HVDC, 500 kV	130	Tjele (DK), Kristiansand (NO)	375
DK-W – NL, COBRAcable	Energinet.dk/Tennet	700	design & permitting	HVDC, 320 kV	350	Endrup (DK), Eemshaven (NL)	630
DK-W – NO, Skagerrak	Energinet.dk/Statnett	1000	in operation	HVDC, 250 kV & 350 kV	n/a	Tjele (DK), Kristiansand (NO)	n/a
PL – CZ, Dobrzeń – Albrechtice	PSE Operator S.A., CEPS	1385	In operation	400 kV	~70 km	Dobrzeń (PL)	n/a
PL - CZ, Wielopole – Nosovice	PSE Operator S.A., CEPS	1385	In operation	400 kV	~54 km	Wielopole (PL)	n/a
PL – CZ, Kopanina/Bujaków – Liskovec	PSE Operator S.A., CEPS	2 x 400	In operation	220 kV	~62 km	Kopanina and Bujaków (PL)	n/a
PL – SK, Krosno Iskrzynia – Lemesany	PSE Operator S.A., SEPS	2 x 831	In operation	400 kV	~102 km	Krosno Iskrzynia (PL)	n/a
PL – UA, Zamość – Dobrotwór	PSE Operator S.A., NEK Ukrenergo	251	In operation	220 kV	~102 km	Zamość (PL)	n/a

Name of the interconnector	Operator of the connection	Capacity of the transmission (import/export) [MW]	State of development	Type of transmission Voltage	Length of the connection	Connection point	Cost
PL – UA, Rzeszów – Chmielnicka	PSE Operator S.A., NEK Ukrenergo	1300	Currently shut down	750 kV	~206 km	Rzeszów (PL)	n/a
PL – BY, Białystrok – Roś	PSE Operator S.A., (no data available on possible Belarussian TSO)	231	Currently shut down	220 kV	~86 km	Białystok (PL)	n/a

2.2.4. General description of procedures for laying subsea cables and construction of offshore wind farms

DENMARK

Offshore wind farms

The Danish Energy Agency serves as a one-stop-shop for the permitting of offshore wind farms. The following permits are required:

- License to carry out preliminary investigations.
- License to establish the offshore wind turbines.
- License to exploit wind power for a given number of years, and an approval for electricity production.

Projects may be applied for in a tendering process where the TSO provides the necessary environmental impact assessment studies. Alternatively developers may choose to apply through an open-door procedure for a site chosen by the developer. The developer has to provide the full environmental impact assessment, also including required transmission infrastructure in this case.

The TSO and if necessary the affected DSO are obliged to connect the offshore wind farm and strengthen the grid, if necessary, in due time. Energinet.dk will also build and own the offshore high voltage station. In projects using the open-door procedure the wind farm owner pays for the electricity transmission to land. Elsewise Energinet.dk carries the costs.

Subsea cables

The ownership of the export cable will be with Energinet.dk for offshore wind farms. When going through an open-door procedure, however, the export infrastructure has to be paid for by the wind farm owner.

Typically Energinet.dk will be responsible for the installation of the export cables and will therefore have to acquire the necessary permits. The investment will have to be approved by the Ministry of Climate, Energy and Building. The same is valid for subsea interconnectors.

The Danish Nature Agency has to provide the permission on an environmental impact assessment. Affected municipalities will also have to amend their spatial plans.

The Danish Energy Agency is the responsible authority for the entire offshore infrastructure related to a wind farm, while the onshore infrastructure is the responsibility of the Nature Agency as well as the affected municipalities.

For offshore wind tenders on the other side, a time schedule is provided by Energinet.dk for the whole process until operation of the turbines. Both the time schedules for Horns Rev 3 as well as Kriegers Flak foresee an administrative process of 2 years before granting of the permission for the offshore work. Typically one year is required to collect base line data. An EIA is expected to be finished the following quarter. Half a year is scheduled for public hearings and potential adjustments, and half a year, partially overlapping the time of public hearing, is planned for finalizing the permissions.

For an open-door procedure the time for planning should expected to be longer. The complicated international process of interconnectors may also result in longer time horizons in the permitting of such projects.

GERMANY

Offshore wind farms:

Depending on the section of the sea the responsibility for the approval lies with an administrative body:

- Coastal zone: Within the 12 mile zone the relevant federal state for the section of coast is responsible for the approval; they conform to the federal emission protection law.
- EEZ: responsibility of the BSH in accordance with the offshore installations ordinance (SeeAnlV).

The approval of OWFs was carried out by means of a planning permission decision. **The planning permission decision** by the BSH has a concentrating effect - no further future decisions by authorities are necessary.

The process of granting the permission consists of several phases. Two rounds of participation are held, with stakeholders such as the regional Waterways and Shipping Directorates, mining authority, Federal Environmental Agency, Federal Agency for Nature Conservation, associations dealing with nature protection, commercial and small craft shipping, fisheries, wind energy. The second consultation is also open to the public.

On the basis of the environmental studies, the applicant prepares an **Environmental Impact Assessment (EIA)**. A risk analysis dealing with the probability of vessels colliding with wind farm installations is also mandatory.

After having received the documentation from the applicant, the BSH passes it on to the competent authorities and associations, asking them to comment. This is followed by a discussion, during which the comments and information concerning the marine environmental features to be protected, the subject of navigational safety, and other interests and uses are discussed with all stakeholders.

Then, the BSH reviews whether the requirements for granting approval have been met. At the same time, the competent regional Waterways and Shipping Directorate reviews whether consent can be granted with a view to the safety and efficiency of navigation.

After both authorities have consented to the application and approval has been granted, a **notification of approval** is issued. An important part of each approval granted by the BSH for an offshore wind farm is the incidental provisions, which are issued in a largely standardised form. They include, among others, a limitation of the approval to a 25-year period, the requirement to start building the installations within 2,5 years after receiving the notification of approval, as well as other requirements most importantly concerning safety issues, construction methods and environmental and noise reduction requirements the geotechnical study.

Transformer platform and grid connection

In general each offshore wind farm is provided with its own transformer platform to which all wind energy plants are connected in bundles with inner park cables. The provider of the windfarm is responsible for the transformer platform. With HVDC connections (e.g. in the EEZ of the North Sea) the power from several neighbouring wind farms is usually bundled on a further mutual transmission platform in the sea and then led onshore from there (so-called cluster connections).

Since 2006 TSOs in Germany are obliged by law to provide grid access, so-called ´power points´ at sea, to OWF developers. Grid connections from offshore wind farms are by law defined as part of the transmission grid in Germany.

<u>Subsea cables:</u>

An important distinction of the procedure for laying offshore cables in Germany is that required corridors are first determined on a central level. This is done through the **Federal Trade Plan for Offshore** for the German Economic Zone, developed by the German Federal Maritime and Hydrographic Agency (BHS). When drawing up this document, an extensive **Strategic Environmental Assessment** (SEA) is carried out in accordance with the Environmental Impact Assessment Act.

Grid expansion is planned through five steps (the description of the relevant documents can be found in subchapter 2.1.1.).

Approval procedure:

The laying and operation of transit pipelines and transit submarine cables on the German continental shelf in the area of the North and Baltic Seas is subject to approval by the German Federal Agency for Nature Conservation (BSH).

Applications for approval should be submitted with enclosed documentation describing the type and scope of the project and, in particular, possible impairments of objects of legal protection (life, health, property, public interests). Important public interests are, e.g., the operation and effectiveness of facilities for shipping and aids to navigation, use of shipping routes and airspace, navigation, fisheries, flora and fauna, the laying, operation, and maintenance of submarine cables and pipelines as well as oceanographic and other scientific research, health of the ocean, and the security of the Federal Republic of Germany.

The following agencies comment on the project, pointing out possible detrimental effects:

- The 28 Regional Waterways and Shipping Directorates,
- Federal Research Centre for Fisheries,
- AlfredWegenerInstitute,
- Federal Agency for Nature Conservation,
- Naval Support Command,
- other cable and pipeline operators.

Approval has to be denied if an impairment of objects of legal protection or of overriding public interests cannot be prevented or compensated by additional provisions in the approval.

SWEDEN

The main permission needed is according to the Environmental law (Miljöbalken). For smaller projects the County Administrative Board could give the approval. Larger projects is decide by the Land and Environmental court. Large offshore installations cable or turbines will probably require government approval.

The process always starts with a consultation with the deciding authority. As a result of this consultation the following issues are decided: the necessary content of the application, the scope of the EIA and the authorities that need to be consulted.

The process will take several years, in best case 2-3 years but can take much longer depending on the project. Early consultations with key stake holders and a willingness to adjust the plans to avoid serious conflicts it the best way to reduce lead time.

The detailed content of the EIA will be decided together with the deciding authority as the first step in the process.

Offshore/onshore HV connection stations will be evaluated together with the OWE/cable, one permission including all necessary installations and activities.

POLAND

<u>Offshore wind farms</u>

The following administrative decisions need to be issued:

- The permit to erect and exploit artificial islands,
- the decision on environmental conditions,
- the construction permit.

In Polish maritime areas an OWF may be located only within the exclusive economic zone (12 nautical miles from shore).

The **permit to erect and exploit artificial islands** is issued upon the application of an investor, by the minister in charge of maritime economy, after receiving the opinions of six ministers: in charge of the economy, culture and cultural heritage, fisheries, environment, internal affairs and the Minister of National Defence.

It is issued for the period necessary for the erection and exploitation of artificial islands, constructions and devices, however, the period cannot exceed 30 years and can be extended by another 20 years.

The environmental impact assessment (EIA) procedure is obligatory for offshore wind farms and it is concluded by issuing a **decision on environmental conditions (DSU)**. The body responsible for the issuance of DSU for projects executed in the maritime areas (in part or as a whole) is the Regional Director for Environmental Protection. The Director analyses EIA report presented by the investor and is obliged to consult with a director of an appropriate maritime office and a competent body of the Chief Sanitary Inspectorate regarding the project execution conditions, as well as to organize social consultations. A trans-boundary procedure will be initiated if the project might potentially environmentally affect another state. This procedure will apply to most OWF projects.

According to Art. 28 par. 1 of the Construction Law (CL), construction works can be initiated only on the basis of a final decision on the issuance of the **construction permit**.

The authority in charge of the procedure related to the issuance of the permit to construct an offshore wind farm and the accompanying infrastructure at sea is the voivodeship governor and the permit to construct the onshore infrastructure will be issued by the regional authority (starostwo).

<u>Subsea cables</u>

The procedures for interconnector cables and the export cables is identical in Poland.

Seabed cables included in the external connection infrastructure of an OWF (located within the area of the exclusive economic zone and the territorial sea) require the issuance of separate permits to lay and maintain seabed cables. The legal basis for the issuance of those permits is given in Art. 26 and Art. 27 of the Act on Marine Areas of the Republic of Poland and Maritime Administration (UOM) - separate regulations for the territorial sea and for the EEZ.

The permit to lay and maintain the seabed cables and pipelines in **internal waters and territorial sea** is issued by the director of the appropriate maritime office (Art. 26 of UOM). In the event that the infrastructure crosses zones in the jurisdiction of two separate maritime offices, two separate permits need to be issued.

The decision containing the permit to lay and maintain seabed cables and pipelines in **Polish exclusive economic zone** is issued by the minister in charge of maritime economy, after receiving the opinion of the minister in charge of the environmental issues (i.e. 1 of UOM). If the maritime spatial plan is adopted the permit will be issued by the maritime office.

According to Art. 27b of UOM, the authority issuing the permit to lay and maintain seabed cables and pipelines within the territorial sea shall charge the entity requesting the permit with the amount equal to 300 calculation units specified in Art. 55 of the said Act (the equivalent of approximately 339 EUR, as of 15th of May 2014).

This fee does not refer to the permit to lay and maintain seabed cables and pipelines within the Polish EEZ.

The Act does not provide the period, for which the permits to lay and maintain the seabed cables and pipelines are issued. This means that these permits are issued for an indefinite period.

The next steps in the procedure are:

- Obtaining the decision on the environmental impact assessment, issued by the Regional Directorate for Environmental Protection and consulted with the Maritime Office, the Sanitary Inspectorate with jurisdiction in the given area and the Military Sanitary Inspection.
- Obtaining the decision on the site location of a public-purpose investment issued by the governor of the municipality and consulted with the head of the Maritime Office, Regional Directorate for the Protection of the Environment and the Voivodship Conservator of Monuments (if necessary).
- Obtaining the construction permit, issued by the Voivode and consulted with the Maritime Office and local government bodies.

2.2.5. Conclusions

1. **Difficulties in balancing of RES, including OWE** due to low flexibility of energy systems and insufficient storage capacity. In Poland for example this is one of the causes of **limited connection capacity for wind energy, including OWE.** Better interconnectivity of the Baltic Region may facilitate balancing through connection to storage capacities in Nordic countries.
2. **Complicated permitting procedures for OWF and subsea cables -** only Denmark has adopted the concept of one-stop-shop which seems to be the most investor friendly path. In Germany the permitting for subsea cables is divided between central bodies (for EEZ) and Federal States (territorial sea) which is similar in Poland.
3. **Lack of strategic EIA regarding offshore wind energy** – only Germany and Denmark have performed strategic EIA for OWE. Such approach helps identify optimal locations for OWFs and minimize the impact of OWE on the environment.
4. **New interconnectors will be required in view of creating the single energy market and new interconnectivity goals –** Poland for example is part of the single energy market only through the SwePol Link.
5. **In Poland (Sweden?) the permitting procedures and export cable planning is performed by investors whereas in Denmark and Germany it is done by TSOs.**

Electricity grid maps are presented in annexes 4 through 7.

2.3. Market

2.3.1. Level of support for offshore wind energy

DENMARK

At the time of writing offshore wind tenders have resulted in the following settlement prices:

- Horns Rev 2: 518 DKK/MWh (67,34 EUR/MWh) for 10 TWh
- Rødsand 2: 629 DKK/MWh (84,28 EUR/MWh) for 10 TWh
- Anholt: 1051 DKK/MWh (140,83 EUR/MWh) for 20 TWh

As explained in chapter 2.1.2, the alternative way of obtaining support is the open door procedure. In this case, the support granted is the same as for onshore turbines: a fixed premium of 250 DKK/MWh, capped whenever the total settlement price (market price + premium) reaches 580 DKK/MWh; in addition a compensation of 3 EUR/MWh is paid for balancing.

GERMANY

The EEG currently provides two different approaches of remuneration for offshore wind farms which started operation before January 1st, 2018.

- Claim of the initial remuneration of 15.4 ct/kWh over a period of 12 years or
- Claim of an initial remuneration of 19.4 ct/kWh for a total of 8 years (the so-called optional acceleration model)

After the corresponding period the basic remuneration returns to a fixed level of 3.9 ct/kWh. The level of support degresses from 2018. The degression amounts for the remuneration of 15.4 ct/kWh to 0.5 ct in 2018, 1.0 ct in 2020 and from 2021 0.5 ct each year. For the accelerated model with 19.4 ct/kWh the degression amounts to 1.0 ct each year from 2018

Individual regulations do, however, exist for the continuation of the initial remuneration of 15.4 ct/kWh depending on the distance between the wind park and the coast and the water depth at the location. The period in which the increased initial remuneration of 15.4 ct/kWh is paid is extended by 0.5 months for every full nautical mile of distance between the system and the coast over twelve nautical miles and by 1.7 months for each full metre of water depth exceeding a depth of 20 metres.

This special regulation is also valid for wind farms for which the operator has selected the higher rate of remuneration of 19.4 ct/kWh for a period of 8 years in accordance with the acceleration model. However, only the remuneration of 15.4 ct/kWh is then due for the extension period.

Table 8. Overview of remuneration for offshore wind energy

Year of commissioning	Higher initial remuneration [ct/kWh]	Initial remuneration in the acceleration model [ct/kWh]
2014	15.4	19.4
2015	15.4	19.4
2016	15.4	19.4
2017	15.4	19.4
2018	14.9	18.4

Year of commissioning	Higher initial remuneration [ct/kWh]	Initial remuneration in the acceleration model [ct/kWh]
2019	14.9	17.4
2020	13.9	-
2021	13.4	-
2022	12.9	-

SWEDEN

Today the Nordpool price is ~33 EUR/MWh, while the revenue from selling the green certificate provides an additional ~22 EUR/MWh, in total around 55 EUR/MWh. This is enough to make land based project in good wind sites profitable. However, for instance one of the OWE investors has claimed his project will not be profitable unless they obtain a total of 77 – 88 EUR per MWh.

POLAND

The level of support for OWE will be determined through a tendering procedure in the future, provided that the planned support scheme based on tenders will be implemented. At present, the price of one certificate, representing the level of support to RES, equaled 42,70 EUR as of the 13th of June 2014.

2.3.2. Planned offshore wind farm projects

Projects of a joint capacity of 2.24 GW are currently under construction or in an advanced conceptual phase in the Germany, Denmark, Sweden and Poland.

Based on an analysis of investor plans and scenarios of TSOs it can be estimated that in a low scenario a further 4,9 GW of installed capacity in offshore wind farms will be built by 2030, while in a high scenario an additional 12,2 GW will operate in those countries.

The table below presents a list of planned offshore wind farms in Germany, Denmark, Sweden and Poland.

Table 9. Planned offshore wind farms in the Baltic Sea

Name of the project	Investor	Capacity of the project (MW)	State of development	Type of transmission Voltage	Length of the export cable (km)	Cost of OWF
Denmark						
Mejlflak	Vindmøllelaug Århus Bugt, Brabrand Net, Galten Elværk, Viby El-Værk, Østjysk Energi, NRGi	60-120 MW	Conceptual phase	MVAC, 33 kV	11	-
Frederikshavn NearshoreLAB	DONG Energy	36	Consent authorized	MVAC	5	32
Kriegers Flak	-	600	Conceptual phase	HVAC, 220 kV	distance to shore 15 km	-

Name of the project	Investor	Capacity of the project (MW)	State of development	Type of transmission Voltage	Length of the export cable (km)	Cost of OWF
Omø Syd	European Energy A/S	200-320	Early conceptual phase	-	-	-
Germany						
EnBW Windpark Baltic 2	EnBW Baltic 2 GmbH	288 MW	Under construction since 8/2013, planned start of operation 2014	150-kV-AC-	193 km	1 bn - Euro
GEOFReE	GEO Gesellschaft fur Energie und Okologie	25	Planned but not approved	-	-	-
Arkona Becken Sudost	E.ON/AWE-Arkona-Windpark-Entwicklungs GmbH	288	Planned but not approved	-	-	-
Wikinger	Ibedrola Enevables Offshore Deutschland	400	Planned but not approved	-	-	-
Arcadis Ost	Arcadis Consult / 40% Nordex	350	Planned but not approved	-	-	-
Beta Baltic	E.ON Energy Projects	100	Planned but not approved	-	-	-
Beltsee	Plambeck Neue Energien	274	Planned but not approved	-	-	-
Fairwind		195	Planned but not approved	-	-	-
Seewind	Iberdrola Renovables Offshore Deutschland	90-150	Planned but not approved	-	-	-
Strom-Nord	Iberdrola Renovables Offshore Deutschland	270	Planned but not approved	-	-	-
Windanker	Iberdrola Renovables Offshore Deutschland	342	Planned but not approved	-	-	-
Adlergrund 500	Adlergrund 500	-	Planned but not approved	-	-	-
Adlergrund GAP	BEC-Energie Consult	-	Planned but not approved	-	-	-
Adlergrund Nordkap	BEC-Energie Consult	-	Planned but not approved	-	-	-

Name of the project	Investor	Capacity of the project (MW)	State of development	Type of transmission Voltage	Length of the export cable (km)	Cost of OWF
ArkkonaSee Ost	ArkonaSee Ost	-	Planned but not approved	-	-	-
ArkonaSee Sud	ArkonaSee Sud	-	Planned but not approved	-	-	-
ArkonaSee West	ArkonaSee West	-	Planned but not approved	-	-	-
BalticEagle	Windreich	-	Planned but not approved	-	-	-
Baltic Power East	Windreich	-	Planned but not approved	-	-	-
Baltic Power West	Windreich	-	Planned but not approved	-	-	-
Ostseeperle	Financial Ensurance Offshore Deutschland	-	Planned but not approved	-	-	-
Ostseeschatz	Financial Ensurance Offshore Deutschland	-	Planned but not approved	-	-	-
Sweden						
Stora Middelgrund	Universal Wind Offshore	800 MW	Approved, investment decision pending	-	25-48	-
Kreigers Flak	Vattenfall	640 MW	Approved, investment decision pending	-	32,4	-
Taggen	Wallenstam, Triventrus, Vattenfall	415	Approved, investment decision pending	-	-	-
Trolleboda	Vattenfall	150	Approved, investment decision pending	-	6	-
Urgrunden II	E.ON	90	Approved, investment decision pending	-	6	-
Storgrunder	Nordan Vind, WPD Scandinavia	265	Approved, investment decision pending	-	11	-
Stenkalles grund	Rewind energy	90	Approved, investment decision pending	-	5	-
Blekinge Offshore	Blekinge Offshore	2500	Application submitted	-	10	-
Finngrunden	WPD Scandinavia	1500	Application submitted	-	40	-

Name of the project	Investor	Capacity of the project (MW)	State of development	Type of transmission Voltage	Length of the export cable (km)	Cost of OWF
Hakefjorden	Goteborg Energi	59	Application submitted	-	-	-
Kattergatt Offshore	Favonius	282	Application submitted	-	8-13	-
Sodra Midsjobanken	E.ON	700	Application submitted	-	90	-
Vindpark Markiven	Rewind Energy	30-60 MW	Application being prepared	-	-	-
Svenska Bjorn Offshore	Solid vind	660 MW	Application being prepared	-	64	-
Petlansskar	Petlandsskar Vind	90 MW	Application being prepared	-	-	-
Klockstarnan	NordanVind, WPD Scandinavia	660 MW	Application being prepared	-	17	-
Poland						
Bałtyk Środkowy III	Kulczyk Investments	1200	Grid connection conditions issued; environmental procedure initiated	-	60-80 km	~4.2 bln EUR
Bałtyk Środkowy II	Kulczyk Investments	1200	Location permit issued, environmental procedure initiated	-	-	~4,3 bln EUR
Baltica-3	PGE	1045,5	Grid connection conditions issued, environmental procedure initiated	-	-	~3.1 bln EUR
Baltica-2	PGE	1202	Location permit issued, environmental procedure initiated	-	-	~4,3 bln EUR
Bałtyk Północny	Kulczyk Investment	1560	Location permit issued, environmental procedure initiated	-	-	~5,6 bln EUR
Baltica-1	PGE	1202,5	Location permit issued, environmental procedure initiated	-	-	~4,3 bln EUR
C-WIND	DEME	200	Location permit issued, environmental procedure initiated	-	-	~0,7 bln EUR
Baltic Power	PKN Orlen	1200	Location permit issued, environmental procedure initiated	-	-	~6,2 bln EUR

Name of the project	Investor	Capacity of the project (MW)	State of development	Type of transmission Voltage	Length of the export cable (km)	Cost of OWF
Baltex	Baltex Energia	-	Location permit issued	-	-	-
Baltex	Baltex Energia	-	Location permit issued	-	-	-
B-Wind	DEME	200	Location permit issued	-	-	~0,7 bln EUR
Baltic Trade and Invest	Baltic Trade and Invest sp. z o.o.	135	Location permit issued	-	-	~0,5 bln EUR
Baltic Wind Development	Baltic Wind Development sp. z o.o.	-	Location permit issued	-	-	-
Aegir 4	Energa	-	Location permit issued	-	-	-
Baltic Wind Power	Energy Invest Group	-	Location permit issued	-	-	-
Generpol G4	Generpol	-	Location permit issued	-	-	-
Generpol G42	Generpol	-	Location permit issued	-	-	-
Generpol G43	Generpol	-	Location permit issued	-	-	-
Generpol G3	Generpol	-	Location permit issued	-	-	-
Generpol G44	Generpol	-	Location permit issued	-	-	-
Generpol G25	Generpol	-	Location permit issued	-	-	-
Generpol 2	Generpol	-	Location permit issued	-	-	-

2.3.3. Conclusions

1. **High disproportion of level of support for OWE** - from ~55 EUR/MWh in Sweden to ~140 EUR/MWh in Denmark (for Anholt wind farm). Low level of support e.g. in Poland and Sweden may cause a barrier for offshore wind farm projects.

2. **High OWE potential in the Baltic Sea** - depending on the realization of planned projects additional 4.9 to 12.2 GW (depending on the realization of planned OWF) in OWE may be developed by 2030 only in project partner countries i.e. Germany, Denmark, Sweden and Poland (currently in EU 6,5 GW in OWE installed). It creates a great market potential.

2.4. Maritime spatial planning

2.4.1. State of maritime spatial planning in partners countries

Maritime spatial planning is an important measure in dealing with conflicts regarding use of maritime areas for different purposes. Apart from offshore wind farms, maritime spatial plans should include: concessions for the exploration of oil and natural gas, mining areas, disputed areas (e.g. the Polish-Danish disputed area), areas protected for environmental reasons (e.g. Natura 2000 sites), navigational routes, areas with special military significance (e.g. used for military training), existing infrastructure (e.g. cables and pipelines), cultural sites, landscape concerns, the use of certain areas for tourism purposes.

DENMARK

Denmark does not yet apply an overall maritime spatial plan. Issues regarding the use of sea areas for various purposes are handled by specific authorities, such as:

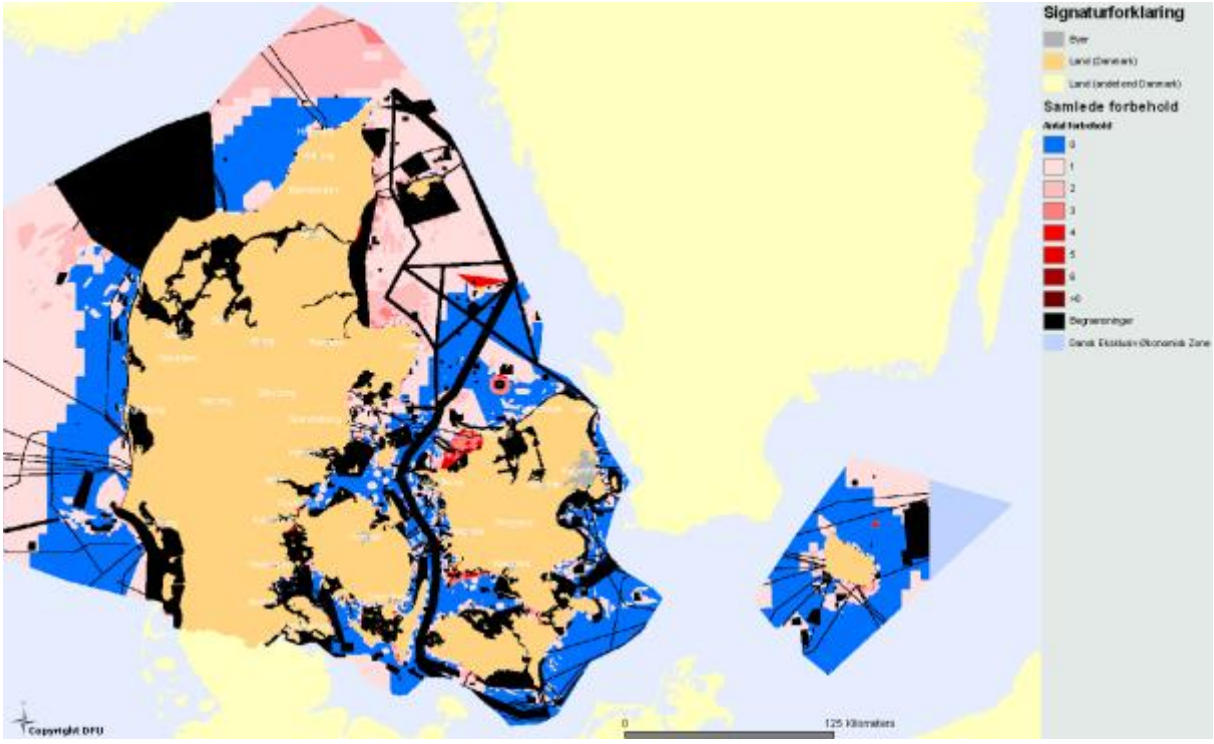
- Offshore wind energy – Danish Energy Agency
- Shipping routes – Danish Maritime Authority
- Military exercise areas – Defence Command
- Flooding risk management – Danish Coastal Authority
- Environmental protection and resource areas – Danish Nature Agency
- Fishery regulation – Danish AgriFish Agency

Activities are coordinated amongst the different authorities and other stakeholders through a system of public hearings and consultations.

In 2010 the Danish government formulated a maritime strategy including a general goal of enhancing maritime spatial planning. Based on this strategy a working group has assessed the possibilities on the further development of such planning. Several strategies are proposed. The working group, however, also proposes to await the result of the process at EU level. Surveys on the status of marine spatial planning have been conducted under the projects PartiSEApate in 2013 and Seanergy 2020 in 2011. Key issues related to marine spatial planning in a Nordic context have been assessed by the Nordic Council of Ministers.

Although an official maritime plan does not exist, a map covering different uses of the Danish sea is provided by DTU Aqua – National Institute of Aquatic Resources.

Figure 8. Map covering uses of the Danish sea



GERMANY

The process of maritime spatial planning in Germany was triggered by a flood of applications for the development of offshore wind farms, which took place after the establishment of a guaranteed subsidy for electricity generated by wind power. Various project proposals were overlapping in space and caused concerns for the effects on the marine environment and on other important users.

In 2007, the German Federal Maritime and Hydrographic Agency (BSH) drafted multiple-use marine spatial plans (and associated environmental reports) for the German exclusive economic zones in the North Sea and the Baltic Sea.

Marine Spatial Planning (MSP) in Germany is based on the Federal Land Use Planning Act that was extended to the EEZ. Spatial plans for the territorial sea are developed by the Federal States. The German plans are regulatory and enforceable. The federal plan for the North Sea went into effect in September 2009; the federal plan for the Baltic Sea in December 2009.

The map of the German maritime spatial plan is presented below:

Figure 9. Spatial management plan of German maritime areas (source: Federal Maritime and Hydrographic Agency)

SWEDEN

Sweden has no maritime spatial planning but the need has been identified and The Swedish Agency for Marine and Water Management, SwAM, has been appointed as responsible as responsible for maritime planning. A report on the current state of maritime spatial planning is available at the Agency's website.

POLAND

A maritime spatial plan for Polish sea areas has not yet been developed. However, in November 2013 the heads of the Maritime Offices in Szczecin, Słupsk and Gdynia signed an agreement on cooperation in the creation of a such a document. The Head of the Maritime Office in Gdynia will coordinate this effort.

An invitation was issued to take part in the consultation process. Among the issues raised by the participants was the possibility of erecting wind farms at sea which would be within sight from the shores, which the local authorities were opposed to. The Polish act on Maritime areas forbids erection of OWF within Polish territorial waters i.e. 12 nautical miles from shore.

Applications have also been submitted to take into account the planned offshore transmission grid in the development of the Plan.

The schedule for the completion of the project envisions the following stages:

- By the end of 2014 an Assessment of the Determinants of the Spatial Management of Polish Marine Areas will be carried out by the Maritime Institute in Gdańsk. Two consultation meetings will take place, planned for June and November.
- By mid-2016 a Strategic Plan will be in place, and public consultations will be carried out.
- By mid-2017 international consultations will be held.

The planned date for completion of the project is 2022, after carrying out supplementary research and developing detailed plans for specific lagoons, port areas and other basins.

2.4.2. Conclusions

1. **Lack of marine spatial plans** - at present only Germany has developed a full maritime spatial management plan. Poland, Denmark and Sweden have taken steps in order to develop maritime spatial plans, and consultations regarding spatial maritime planning have taken place on a regional level. It is crucial to include OWE and offshore grids in the marine spatial plans from the very beginning to minimize administrative risks in the future.
2. There is a wide variety of factors which should be taken into account in spatial planning including such specific factors as UXOs which are abundant in the Baltic Sea.
3. **Spatial data is not always available even to planners** which calls for better integration and coordination of existing data for the Baltic Sea (Poland).

The map of the Maritime Spatial Plan for Germany and maps of spatial barriers in other countries are presented in annexes 7 through 18.

2.5. Stakeholders

A list of stakeholders is presented below. The main groups of stakeholders include regional and central administrative bodies, transmission system operators, investors, sector non-governmental organizations, think tanks, academic institutions, cable and turbine producers, installation and construction companies with experience in offshore wind farm projects and associations/chambers of commerce.

Table 10. List of stakeholders

Name of the organization	Expertise	Contact Person – position	Potential area of involvement in the main project
EWEA	Wind energy network		
Denmark			
Energinet.dk	Transmission System Operator	Kim Behnke, Head of R&D	Cooperation in grid development plans
DONG Energy A/S	Market leader in offshore wind		Potentially interested in the development of an offshore grid
E.ON Danmark A/S	Operator of Rødsand II offshore wind farm		
CONCITO	Green think tank		
Energistyrelsen	Danish Energy Agency, the responsible public authority for offshore wind	Lisbeth Nielsen, Special Adviser	
Vindmølleindustrien	Association for the Danish wind energy industry		Sector organization acting to develop wind Energy in Denmark
Dansk Energi	Association for the Danish energy sector		
Technical University of Denmark	Research institution with expertise in wind energy and energy system analysis		Access to technical expertise and know-how
Aalborg University	Research institution with expertise in sustainable energy planning		Access to technical expertise and know-how
TP Wind	Wind technology networking organizations		

Name of the organization	Expertise	Contact Person – position	Potential area of involvement in the main project
EERA	Research cooperation network		
Danish Export Association	Networking organizations for Danish export industries		
Dansk Erhverv	Danish Chamber of Commerce		
Vestas A/S	Wind turbine producer		
Siemens Wind Power A/S	Wind turbine producer		Access to market data on potential investment costs
MT Højgaard	Building and civil engineering company experienced in offshore foundations		Access to market data on potential investment costs
APRO Wind	Installation and service		Access to market data on potential investment costs
A2SEA	Installation		Access to market data on potential investment costs
Swire Blue Ocean	Installation		Access to market data on potential investment costs
CT Offshore	Offshore cable installation		Access to market data on potential investment costs
ØER	Installation & service		Access to market data on potential investment costs
DHI	Research and consulting institution with expertise in e.g. environmental impact assessment for offshore wind		Access to market and environmental expertise
COWI	Project development and		Access to market

Name of the organization	Expertise	Contact Person – position	Potential area of involvement in the main project
	consulting		expertise
Grontmij	Project development and consulting		Access to market expertise
Rambøll	Project development and consulting		Access to market expertise
Germany			
50Hertz (TSO)	Grid development Baltic Sea, Grid expansion		Guidance, perhaps later help by the establishment of concepts
TenneT	Experience in grid development North Sea		Guidance
EnBW (Operator OWF)	Operator of German OWF (Baltic Sea)		Guidance
BSH (Federal Maritime and Hydrographic Agency	Application procedures Federal Trade Plan	Anna Hunke, Anna.Hunke@bsh.de	Guidance
Deutsche WindGuard GmbH	High experience in on- and offshore project, involved in the EU project North Sea Grid, The manager of the company is a member of the board of the Stiftung Offshore-Windenergie	Dr. Knud Rehfeldt	Experience exchange
Sweden			
Svenska Kraftnät	TSO		Cooperation in grid development plans

Name of the organization	Expertise	Contact Person – position	Potential area of involvement in the main project
WPD	OWF Developer		Potentially interested in the development of an offshore grid
Blekinge Offshore	OWF Developer		Potentially interested in the development of an offshore grid
Vattenfall	OWF Developer		Potentially interested in the development of an offshore grid
Svensk Vindkraftförening	NGO promoting wind energy		Sector organization working to develop wind power
Svensk Vindenergi	Professional organization		
ABB	Cable producer		Access to market data on potential investment costs
Poland			
PSE (Polskie Sieci Elektroenergetyczne S.A.)	TSO	Department of Development: DS@pse.pl +48 22 242 10 46	Cooperation in grid development plans
Kulczyk Investments	OWF developer	+48 22 522 32 00	Potentially interested in the development of an offshore grid
PGE (Polska Grupa Energetyczna)	OWF developer	Reception: +48 22 340 11 77	Potentially interested in the development of an offshore grid
PKN Orlen	OWF developer	Office in Warsaw: +48 22 778 00 00	Potentially interested in the development of an offshore grid

Name of the organization	Expertise	Contact Person – position	Potential area of involvement in the main project
Generpol	OWF developer	Head Office: +48 58 710 35 36	Potentially interested in the development of an offshore grid
DEME	OWF developer	-	Potentially interested in the development of an offshore grid
Polskie Stowarzyszenie Energetyki Wiatrowej (PSEW, eng. *Polish Wind Energy Association*)	NGO	Oliwia Mróz o.mroz@psew.pl +48 91 48 62 535	Sector organization acting to develop wind energy in Poland
Polskie Towarzystwo Morskiej Energetyki Wiatrowej (eng. *Polish Offshore Wind Energy Society*)	NGO	ptmew@ptmew.pl +48 58 500 84 06	Sector organization acting to develop wind energy in Poland
Maritime Institute	Expert organization	+48 058 301-18-79	Database of information on maritime issues and constraints, institute takes part in the preparation of the Maritime Spatial Plan
General Directorate for the Protection of Environment	Administration	Andrzej Dziura, director of Department of Environmental Impact Assessments +48 22 57-92-105	Environmental issues
Regional Directorate for the Protection of Environment in Szczecin	Administration	Bogdan Dobrzyński, Head of Department of Environmental Impact Assessments, bogdan.dobrzynski.szczecin@rdos.gov.pl (91) 43 05 207	Environmental issues
Regional Directorate for the Protection of Environment in Gdańsk	Administration	Wiesława Wawro-Noga, Head of Department of Environmental Impact Assessments, wieslawa.wawro-noga@gdansk.uw.gov.pl, 58 68 36 804	Environmental issues
Maritime Office in Gdynia	Administration	-	Maritime authority, Coordinates preparation of

Name of the organization	Expertise	Contact Person – position	Potential area of involvement in the main project
			Maritime Spatial Plan
Maritime Office in Słupsk	Administration	Inspectorate for spatial development and oversight inp@umsl.gov.pl +48 059 848-19-90	Maritime authority
Maritime Office in Szczecin	Administration	Department for spatial management: +48 91 44 03 552	Maritime authority
Ministry of Environment	Administration	info@mos.gov.pl, +48 22 57 92 900	In charge of environmental issues and exploration and mining of natural resources
Ministry of Infrastructure and Development	Administration	+ 48 22 273 70 00	Coordination on grid development and Maritime Policy of Poland
Gdańsk University of Technology	Academic Institution	+48 58 347 11 00	Access to technical expertise and know-how
West Pomeranian University of Technology in Szczecin	Academic Institution	zut@zut.edu.pl, +48 91 449 41 11	Access to technical expertise and know-how
Electrotechnical Institute, Gdańsk Branch	Academic Institution	instytut@iel.gda.pl +48 58 3431291	Access to technical expertise and know-how
Telefonika	Cable producer	info@tfkable.com +48 (12) 652 5000	Access to market data on potential investment costs
ABB	Cable producer	kontakt@pl.abb.com +48 2222 3 7777	Access to market data on potential investment costs
Polish Economic Chamber of Renewable Energy	Chamber of Commerce	+48 22 548 49 99 pigeo@pigeo.pl	Sector organization acting to develop

Name of the organization	Expertise	Contact Person – position	Potential area of involvement in the main project
			RES in Poland

2.6. List of similar EU funded projects

2.6.1. Kriegers Flak

Kriegers Flak is a shallow area of water located between Denmark, Germany and Sweden, which is particularly suitable for the erection of large offshore wind farms. The international project involves setting up a combined grid solution (CGS), which makes it possible to connect offshore wind farms to an offshore power grid connecting Denmark and Germany. Sweden can also be connected to this interconnector at a later stage.

Objective: The project objective is to create a combined grid solution, connecting German and Danish wind farms in the Kriegers Flak area, through a modular-based combined solution linking the national grid connections. The project partners are 50Hertz Transmission and Energinet.dk.

Project impact: Kriegers Flak Combined Grid Solution will, as opposed to the traditional way of connecting offshore wind power plants by using radial solutions, develop and implement an innovative, cross-border solution which is based on the dual-purpose use of the sub-sea cables, for both transmission of wind energy and energy trade. A Combined Grid Solution at Kriegers Flak will bring renewable energy to European consumers, strengthen the energy markets and increase the security of supply by providing transmission capacity.

Activities: The European Energy Programme for Recovery (EEPR) supports the construction of the HVDC equipment for the multi-terminal VSC-based (voltage source converter) Combined Grid Solution. Equipment includes land and sea cables, sub-stations, and offshore platforms.

Temporal progress: In a Joint Feasibility Study from **2009** the TSOs 50Hertz Transmission, Energinet.dk, and Svenska Kraftnät have been investigating different technical concepts for connecting offshore wind farms (OWFs) at Kriegers Flak in the Baltic Sea - Kriegers Flak 1 (now EnBW Baltic 2) in Germany, Kriegers Flak 2 in Sweden, and Kriegers Flak 3 in Denmark in comparison to a reference case. The reference case is a classical solution where the offshore wind farms are only connected directly to each country. This concept is compared to combined grid solutions based on DC or hybrid technology where the grid connection of the offshore wind farms would also function as an interconnector between Denmark, Germany, and Sweden. One variant of these solutions is selected and referred to in the following as the Combined Grid Solution (CGS).

The feasibility study includes the following assumptions:

- The CGS is the preferred solution from a technical and cost perspective
- Cost benefit analysis shows a positive net benefit for a CGS compared to radial grid connections
- The benefits generated by the CGS are more favourable than for the other technical solutions
- The CGS would pose some challenges for the existing market rules and national regulations in the three countries.
- Permission procedures for CGS are expected to take between 2 and 3 years
- The CGS is a very flexible solution and can be implemented in a step-wise manner

In **2010** Svenska Kraftnät chose to withdraw from the Kriegers Flak project because internal assessments of Svenska Kraftnät show that they do not expect offshore wind farms to be constructed at the Swedish part of Kriegers Flak in the foreseeable future.

At the end of 2010 the EU agreed to award 150 million EUR to Danish Energinet.dk and German 50Hertz Transmission GmbH in support of the establishment of an offshore-power grid at Kriegers Flak.

The project was confirmed in both the GDP **2012 and 2013** from the BNetzA and is a purpose within the "Bundesbedarfsplangesetz"

State of play October 2013: The technical solution for the Kriegers Flak area, involving HVDC technological components, has been defined and a market and business model for the combination of renewable electricity allocation and cross-border electricity trade has been developed. The Final Investment Decision has been taken and construction is expected to start in 2014.

2.6.2. North Sea Countries Offshore Grid Initiative

The North Seas Countries' Offshore Grid initiative (NSCOGI) was formed as the responsible body to evaluate and facilitate coordinated development of a possible offshore grid that maximizes the efficient and economic use of those renewable sources and infrastructure investments. The ten countries involved are Belgium, Denmark, France, Germany, Ireland, Luxembourg, Netherlands, Norway, Sweden and the UK.

The Memorandum of Understanding (MoU) was signed on the 3rd of December 2010 by the 10 countries around the North Seas represented by their energy ministries, supported by their Transmission System Operators (TSOs, organized in the European Network of Transmission System Operators for Electricity ENTSO-E), their regulators (organized in the Agency for the Cooperation of Energy Regulators ACER) and the European Commission together forming the NSCOGI.

Three working groups were created by the MoU in order to take the overarching objective into a set of deliverable to be taken forward:

- WG1 - grid implementation
- WG2 - market and regulation
- WG3 - permissions and planning

As a forum the Initiative identified and tackled barriers to a strategic, coordinated offshore grid development, in particular technical, regulatory, market, legal, planning and authorization issues.

An analysis was conducted to determine the economic viability of two scenarios for connecting offshore wind farms in the region:

- a meshed grid (coordinated offshore and interconnector design, which implies multilateral cross-border cooperation between the North Seas countries),
- a radial grid (point-to-point connection of offshore wind farms and shore-to-shore interconnectors, which implies continuing with mainly uni- or bilateral solutions between countries).

The analysis concluded that the development of a meshed grid was slightly less costly, in the case of a limited deployment of new OWFs. However, in a more ambitious scenario, the benefit of introducing a meshed approach grew.

As a first step towards addressing possible barriers, a set of high-level principles was drawn up for NSCOGI countries to use as guidelines for the development of cross-border transmission infrastructure. The principles cover issues such as planning, grid design, financing, operation of assets, ownership of assets and system charges. The aim is to move towards a more common approach towards such investments in order to facilitate coordinated offshore developments where these might prove to be cost-effective.

2.6.3. List of other similar EU funded projects

Table 11 (further in the document) presents a list of projects with similar goals and areas of focus to the Baltic InterGrid Project. The main areas of focus have been:

- the promotion of OWE and identifying barriers to its development,
- regional maritime spatial planning in the Baltic Sea,
- the development of an offshore grid in the Northern Sea,
- transmission grid expansion planning on a European level.

However, none of the identified projects approach the development of offshore wind energy jointly with the development of the offshore grid in the Baltic Sea area, as the Baltic InterGrid project aims to do.

2.6.4. Conclusions

1. **There is a number of finished or ongoing projects that the Baltic InteGrid can build on.** They mainly target the North Sea, however can prove very useful for the Baltic Sea. The projects/initiatives directly related to Baltic InteGrid initiative are: OffshoreGrid and the follow up project NorthSeaGrid; Kriegers Flak project, NSCOGI initiative.
2. **There is a very high potential to build on the experience gained in other EU projects and thus leap frog certain obstacles.**

Table 11. List of similar projects

Name of the project	Description of the project including main goals	Project partners	Status	Project website	Contact details
South Baltic OFFER	The main objective of the project is to promote, through concerted cross-border actions, offshore wind energy in the South Baltic area and identify industry potential, in terms of production and service offer related to offshore wind energy, in the regions represented by project Partners. Within the project framework, technical cooperation and eventually networking platform for entrepreneurships is planned to be built.	• Rostock Business and Technology Development GmbH • German Offshore Wind Energy Foundation • Guldborgsund Municipality • Risoe Danish Technical University • Solvesborg Municipality • City of Karlskrona • CORPI – Costal Research and Planning Institute • Self-Management Institute • Polish Offshore Wind Energy Society • Pomeranian Centre for Environmental Research and Technology	Finished	http://www.southbaltic-offshore.eu/	+ 49 (0) 381-37719-15 proba@rostock-business.de
PartiSEAPate (Multi-level governance in maritime spatial planning throughout the Baltic sea region)	The project aims to serve as a platform for the international coordination of spatial use of the Baltic sea and balancing the interests of competing sectors.	• Maritime Institute in Gdańsk • Maritime Office in Gdynia • Maritime Office Szczecin • State Regional Development Agency (Latvia) • Baltic Environmental Forum (Latvia) • Latvian Institute of Aquatic Ecology • Klaipeda University Coastal Research and Planning Institute (CORPI) • Region Skane (Sweden) • Swedish Agency for Marine and Water Managament • German Federal Maritime and Hydrographic Agency • Institute of Marine Research (Norway)	Ongoing	http://www.partiseapate.eu/	+48 583019339 joaprz@im.gda.pl

Name of the project	Description of the project including main goals	Project partners	Status	Project website	Contact details
4Power	The project aims to promote a favorable business, innovation climate and regional policy framework facilitating the development of OWE. The results will include developing policy recommendations for the Committee of Regions.	• Province of Groningen • Province of Rimini Sustainable Industries Institute, Dundee College • Latvian Association of Local and Regional Governments • Rostock Business and Technology Development GmBH • Maritime Institute in Gdańsk • Azorina – Society for Environment Management and Nature Conservation • Municipality of Corfu • Malta Intelligent Energy Management Agency • City of Emden • German Offshore Wind Energy Foundation	Ongoing	http://www.4-power.eu/	+31 652584235 p.smale@provinciegroningen.nl
E-Highway 2050	The project aims to develop a top-down planning methodology to provide a first version of a modular and robust expansion plan for the Pan-European Transmission Network from 2020 to 2050, in line with the pillars of European energy policy. The project is aimed at planning the Pan-European Transmission Network, including possible highways, capable of meeting European needs between 2020 and 2050.	• Amprion (Germany) • Brunel Unversity London • CEPS (Czech Republic) • Collingwood Environmental Planning, UK • Universidad Pontificia Comillas • German Energy Agency • ECN (Netherlands) • Elia System Operator (Belgium, Germany) • Ensiel (Italy) • Entso-e • Eurelectric (Belgium) • Europacable (Belgium) • EWEA • E3G (Belgium) • Institute of Power Engineering (Poland) • Instituto Superior Tecnico (Portugal) • Electrical engineering department, University of Leuven (Belgium)	Ongoing	http://www.e-highway2050.eu/	+49 (0)30 72 61 65-600 info@dena.de

Name of the project	Description of the project including main goals	Project partners	Status	Project website	Contact details
		• POYRY • PSE Operator (Poland) • Rede Electrica Nacional (Portugal) • Ricerca sul Sistema Energetico (Italy) • RTE (France) • Swissgrid (Switzerland) • Technofi (France) • Terna (Italy) • TU Berlin (Germany) • T&D Europe (Belgium)			
Wind energy in the Baltic Sea Region 2	The project aims to identify current obstacles for existing and future wind energy projects and elaborate recommendations on how to overcome them, analyze existing storage technologies and new research works in this field regarding their potentials for wind energy storage and promote OWE in an unconventional way – through combining wind energy and art.	• Automotive Industry Institute (Poland) • Baltic Sea Centre of Culture (Poland) • Baltic Windenergy Association (Germany) • City of Kalmar (Sweden) • City of Rostock (Germany) • Energy Agency for Southeast Sweden • Hydrogen Technology Initiative Mecklenburg-West Pommerania • Kalmar Konstmuseum (Sweden) • Linnaeus University (Sweden) • Lithuanian Energy Institute • Polish Wind Energy Society • Regional Planning Association (Germany) • School of Arts (Germany) • Strategic Self-management Institute (Lithuania) • The Electrotechnical Institute Gdansk Branch (Poland) • University of Klaipeda (Lithuania)	Ongoing	http://www.windenergy-in-the-bsr.net/	+49 381 375 971-75 info@baltweg-mv.de

Name of the project	Description of the project including main goals	Project partners	Status	Project website	Contact details
OffshoreGrid	The aim of the study is to develop a scientifically based view on an offshore grid in Northern Europe along with a suited regulatory framework considering technical, economic, policy and regulatory aspects.	• 3E (Belgium) • Forwind – Center for Wind Energy Research (University of Oldenburg, Germany) • Institute of Renewable Energy (Poland) • Senergy Econnect, UK • SINTEF Energy Research, Norway • National Technical University of Athens, Greece • German Energy Agency (dena)	Finished	http://www.offshoregrid.eu/	+32 2 217 58 68 jan.dedecker@3e.eu
EERA-DTOC (European Energy Research Alliance - Design Tool for Offshore Wind Farm Cluster)	The aim of the project is to develop a multidisciplinary integrated software tool for an optimized design of offshore wind farms and clusters of wind farms. The result will be a planning tool for clustering and optimized grid connection of offshore wind farms.	• Technical University of Denmark • European Wind Energy Association • Fraunhofer-Gesellshaft zur Foerderung der Angewandten Forschung E.V (Germany) • Fundacion CENER-CIEMAT (Spain) • Energy Research Centre of the Netherlands • SINTEF Energi AS • Carl von Ossietzky Universitaet Oldenburg (Germany) • Centre for Renewable Energy Sources and Saving (Greece) • Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas (Spain) • Universidade de Porto (Portugal) • University of Strathclyde (United Kingdom) • The Trustees of Indiana University (United States) • Collecte Localisation Satellites SA (France) • Statkraft Development AS (Norway) • Iberdrola SA (Spain) • Statoil Petroleum AS (Norway) • Overspeed GmbH & Co. KG (Germany) • Bard Engineering GmbH (Germany) • HEXICON AB (Sweden)	Ongoing	http://www.eera-dtoc.eu/	Charlotte Bay Hasager, cbha@dtu.dk

Name of the project	Description of the project including main goals	Project partners	Status	Project website	Contact details
		• The Carbon Trust (United Kingdom) • E.ON Sverige AB (Sweden) • Renewable Energy Systems Limited (United Kingdom)			
Twenties	The aim of the project is to present solutions that the network operators should implement to allow for off-shore wind development, through increasing the flexibility of the transmission grid. A final report is available on the EWEA website.	• Red Electrica de Espana (Spain) • Dong energy • Iberrdola • Reseau Transport Delectricite • Elia System Operator • Energinet • DTU Wind Energy (Denmark) • Electricite de France • Alstom • Tennet TSO • Institute for Research in Technology Universidad Pontificia de Comillas • Fraunhofer IWES • SINTEF Energiforskning A/S • Gamesa • Siemens • 50hertz • EWEA • CORESO • ABB • Instituto de Engenharia de Sistemas e Computadores de Porto • University College Dublin • Ricerca sul Sistema Energetico • Institute for Energy and Environment, University of Strathclyde • Unviersity of Liege • Electa Group, Electrical Engineering	Finished	http://www.twenties-project.eu/	-

Name of the project	Description of the project including main goals	Project partners	Status	Project website	Contact details
		Department, Katholieke Universteit Leuven • Universite Libre de Bruxelles			
NorthSeaGrid	The NorthSeaGrid project, partly funded by the Intelligent Energy Europe (IEE) program, is the follow-up project of OffshoreGrid. OffshoreGrid – a flagship project of the IEE - investigated an optimal design for a meshed offshore grid directly building on and integrating offshore wind energy infrastructure. NorthSeaGrid builds further on the results and aims to investigate why these projects are not being built today.	• Centre for European Policy Studies (CEPS) • Deutsche WindGuard (DWG) • Det Norske Veritas AS (DNV) • IC Consultants Ltd (ICON) • Stichting Energieonderzoek Centrum Nederland (ECN) • 3E NV/SA (Coordinator)	ongoing	http://northseagrid.info/	Tel: (+32 2) 229 39 11 Fax: (+32 2) 219 41 51 Email: info@northseagrid.info
BaltSeaPlan	The € 3,7 m project BaltSeaPlan (2009-2012) accompanied the EU Maritime Policy by supporting the introduction of Integrated Maritime Spatial Planning and preparation of National Maritime Strategies within Baltic Sea Region. It also contributed to the implementation of the HELCOM recommendation on broad-scale Maritime Spatial Planning and the VASAB Gdańsk Declaration.	• German Federal Maritime and Hydrographic Agency • World Wide Fund for Nature Germany • Ministry of Transport, Bulding and Regional Development Mecklenburg-Vorpommern • Maritime Office in Szczecin • Maritime Office in Gdańśk • Maritime Office in Gdynia • National Environmental Research Institute (Denmark) • Royal Institute of Technology (Sweden) • Swedish Environmental Agency • Estonian Marine Institute of University of	Finished	http://www.baltseaplan.eu/	+49 (40) 3190 – 3520 nico.nolte@bsh.de

Name of the project	Description of the project including main goals	Project partners	Status	Project website	Contact details
	Activities a) Improve the joint information base / stocktaking b) Include Spatial Planning in National Maritime Strategies c) Develop a Common Spatial Vision for the Baltic Sea d) Demonstrate MSP in 8 pilot areas: Danish Straights / T-Route (DK), Pomeranian Bight (DE/DK/SE/PL), Western Gulf of Gdansk (PL), Middle Bank (SE/PL), Lithuanian Coast (LT), Western Coast of Latvia (LV), Pärnu Bay (EE), Hiiumaa and Saaremaa Islands (EE) e) Lobbying and capacity building for MSP	Tartu • Baltic Environmental Forum Estonia • Coastal Research and Planning Institute (Lituania) • Baltic Environmental Forum (Lituania) • Baltic Environmental Forum (Latvia)			

3. Barriers to the development of offshore wind energy and an integrated offshore grid

In terms of **legal and political conditions** the main factors identified as barriers were:

- Lack of uniform support schemes for offshore wind energy.
- The support schemes, which have all renewable technologies competing for the support based on the proposed price of electricity make development of OWE difficult.
- Lack of targets and strategy towards the development of offshore wind power in some countries.

In terms of **infrastructural conditions** the following main barriers were identified:

- Inefficient consenting procedures. Administrative issues require the participation of multiple authorities lead to delays. The lack of a single entry point for applicants and unclear procedures for co-ordination between the different departments tends to delay the permitting process. On the other hand, the current organization of a one-stop-shop at the Danish Energy Agency in Denmark is efficient and keeps administrative costs low.
- Grid extension and development of new flexible capacities is needed.
- Difficulty in connecting offshore wind to the electricity grid caused by lack connection capacity.
- Lack of large scale energy storage systems which would help in balancing energy from offshore wind.
- Blocking connection capacity by virtual investment projects (projects with virtually no chance of implementation) is an issue in some countries.
- Loop flows are an important obstacle to planning bilateral trade in electricity between Poland and Germany.

In terms of **market conditions** the following main barriers were identified:

- The high cost of offshore wind projects. A number of other barriers derive from this issue, such as the lack of social acceptance for the high cost of required support.
- Higher risk premiums demanded by investors due to the high uncertainty level caused by the costs, which causes problems with financing investments.
- The inability to compete with cheaper RES technologies for support in technologically-neutral support schemes.
- Problems in the supply chain, such as the limited number of turbine and seabed cable manufacturers.
- Insufficient level of state support in some countries.

The identified barriers in terms of **maritime spatial planning** were:

- The lack of developed maritime spatial plans in most countries, as a factor complicating the investment process.

ANNEXES

Annex 1. Full list of barriers to the development of offshore wind energy

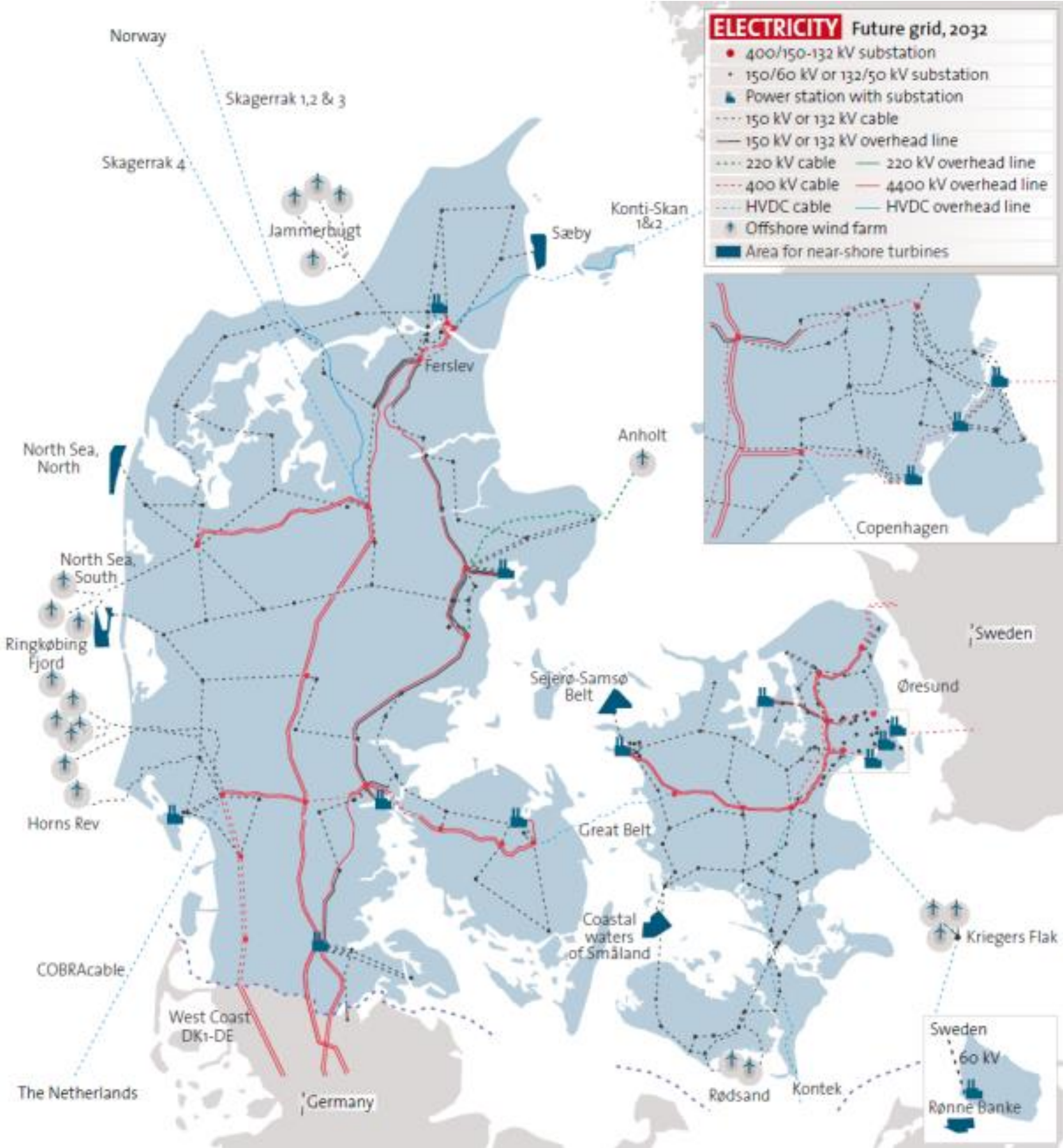
	Denmark	Germany	Sweden	Poland
Market conditions	• Substantial costs of offshore projects could lower social, and thus political, acceptance and introduce barriers. • The high price in the tendering process for the Anholt project has been acknowledged as a problem and measures are taken to make future tenders more competitive.	• Limited number of turbine manufacturers offering commercial offshore turbines. • The high uncertainty levels due to the lack of sophisticated technology has led to higher risk premiums demanded by investors, which makes it difficult to secure financing for offshore projects.	• The main barrier is the investment cost. The combined Nordpool price and the income from the green certificates do not suffice to make OWF projects profitable.	• Excessive investments costs associated with OWF, lack of competitiveness in terms of other RES technologies. • Limited availability of investment resources, including banks. • Strong competitiveness of foreign RES support mechanisms. • Significant oversupply of certificates of origin and lack of a system for the maintenance of RES support mechanism stability. • Maintaining excess of demand over supply in terms of technology delivery and services for OWF market, and therefore lack of reductions in the investment costs. • Lack of national wind turbine and seabed cable manufacturers.
Legal conditions	• Key barriers not related to regulatory framework and administrative hurdles.	• Inefficient consenting procedures. Permission for construction is required from a number of different	• The current scheme for RES does not provide sufficient support for most OWE projects, due to higher	• The lack of goals in terms of OWE development (specific targets of installed capacity) in

	• The current organization of a one-stop-shop at the Danish Energy Agency is efficient and keeps administrative costs low.	authorities within the country. Administrative issues lead to delays. • The lack of a single entry point for applicants and unclear procedures for co-ordination between the different departments tends to delay the permitting process.	investment cost for OWFs in comparison to other RES.	strategic policy. • The support scheme, which have all renewable technologies competing for the support based on the proposed price of electricity make development of OWE difficult. • The system for the allocation of sites for OWF does not guarantee the selection of the most reliable investors and it does not verify projects in terms of their feasibility, which results in large numbers of "virtual projects", which block connection capacity. • The owner of the OWF is burdened with the costs of connecting the wind farm to the NPS (National Power System) connection point located onshore. • Lack of incentives for cooperation between the OWF investors with the TSO in relation to the development of the offshore grid.
Infrastructural	• Grid extension and development of new flexible	• Difficulty in connecting offshore wind to the electricity grid (delays in the		• Blocking connection capacity by virtual investment projects (projects with virtually no chance

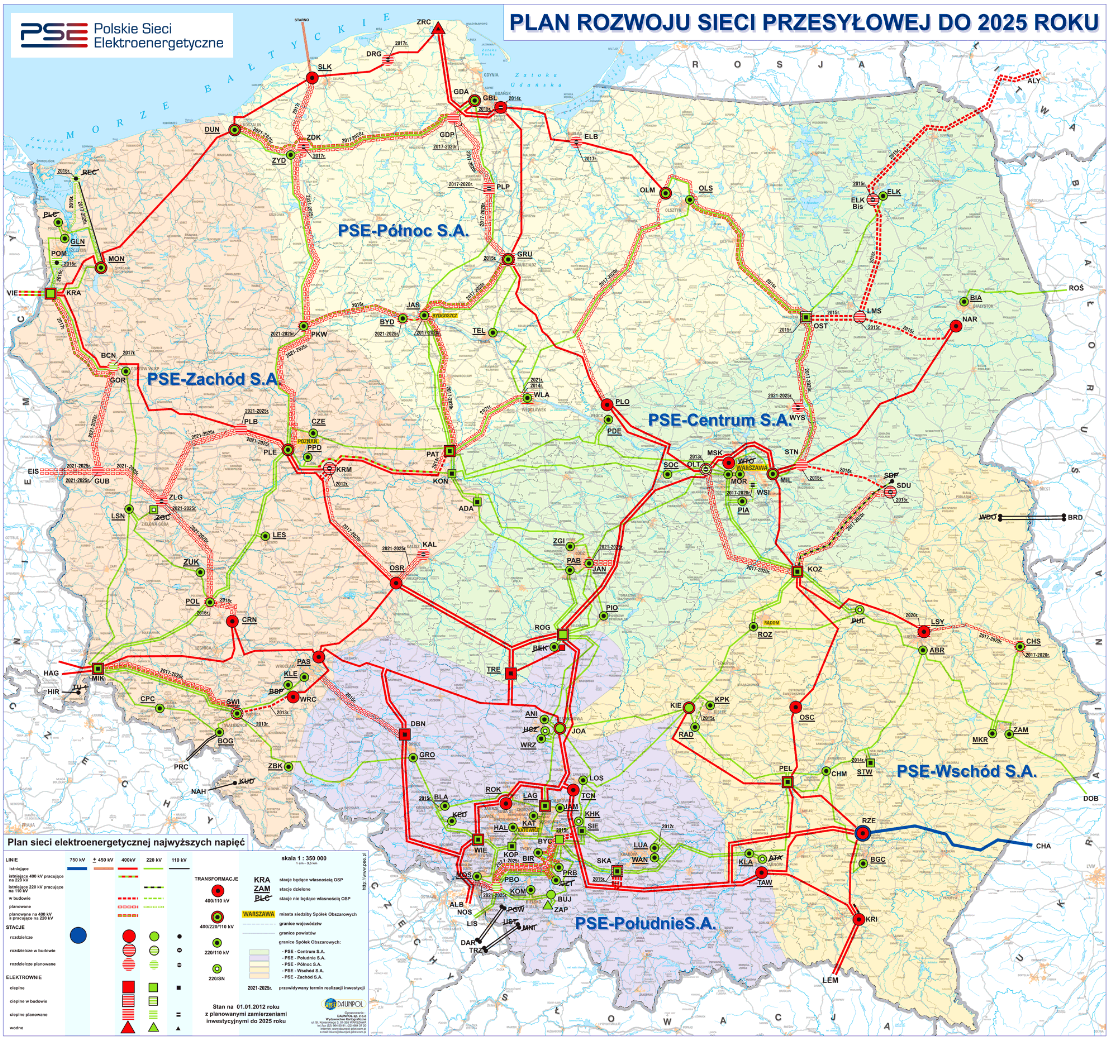
conditions	capacities is needed. • Bottlenecks outside of Denmark will one day become an issue.	implementation of the HVDC grid connections in the North Sea which delay the realisation of the offshore wind farms). • Grid extension is needed.		of implementation). • Lack of offshore power grids and NPS connection points located within the maritime areas. • Poor land transmission grid in the northern areas of Poland. • Lack of sufficient logistics facilities - ports fail to meet the criteria to support OWF, lack of storage areas, insufficient capacity of production plants, lack of OWF construction vessels. • Lack of energy storage systems, insufficient capacity of pumped-storage power stations.
Spatial and environmental conditoins	• A more integrated maritime spatial plan could be an advantage and accelerate project development.			• Lack of the spatial development plan for maritime areas, which would indicate the areas intended for the development of OWF, not colliding with the other methods of exploiting the maritime areas. • Lack of indicated infrastructure corridors, in which the seabed cables connecting the OWF with the shore could be placed. • Lack of marine environment survey standards established and approved by appropriate

				authorities environmental impact assessment procedure. • Lack of objective results of marine environment research, which could serve as a reference for the research carried out by investors for the purpose of EIA.
Technological conditions		• Increased Research and Development Activities (R&D) to improve foundation technologies limited to shallow waters are needed. Offshore is still a relatively new technology compared with onshore, and so there are still some technological issues involved. Some of the projects that are already online have in the past had issues with the reliability of turbine components.		• Lack of efficient and approved energy storage systems for the excessive energy production by OWF. Expensive and not easily available HVDC systems increasing the efficiency of OWF.

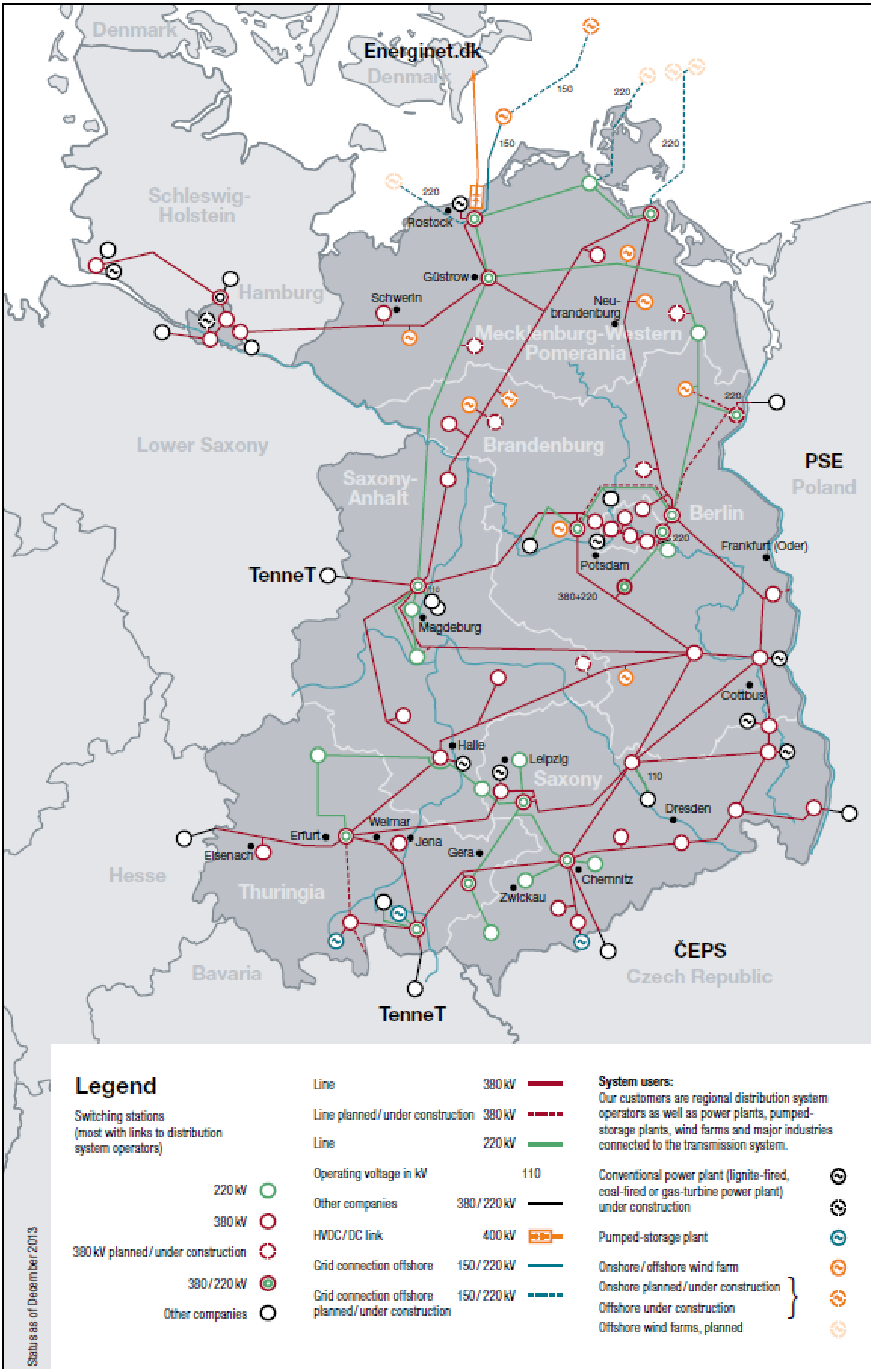
Annex 2. Planned future Danish transmission grid 2032



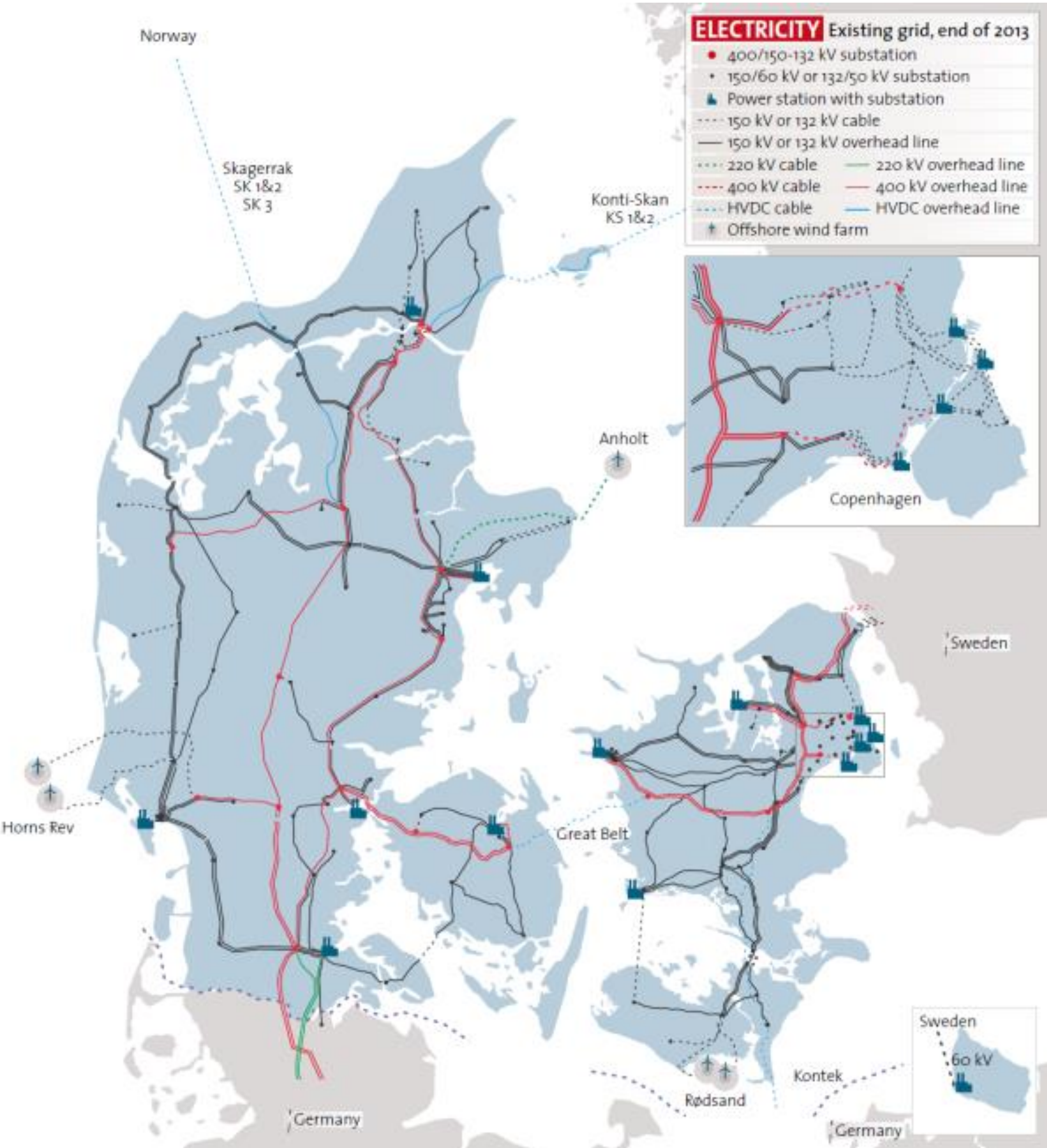
Annex 3. Map of the development plan of the Poilsh electricity grid until 2025



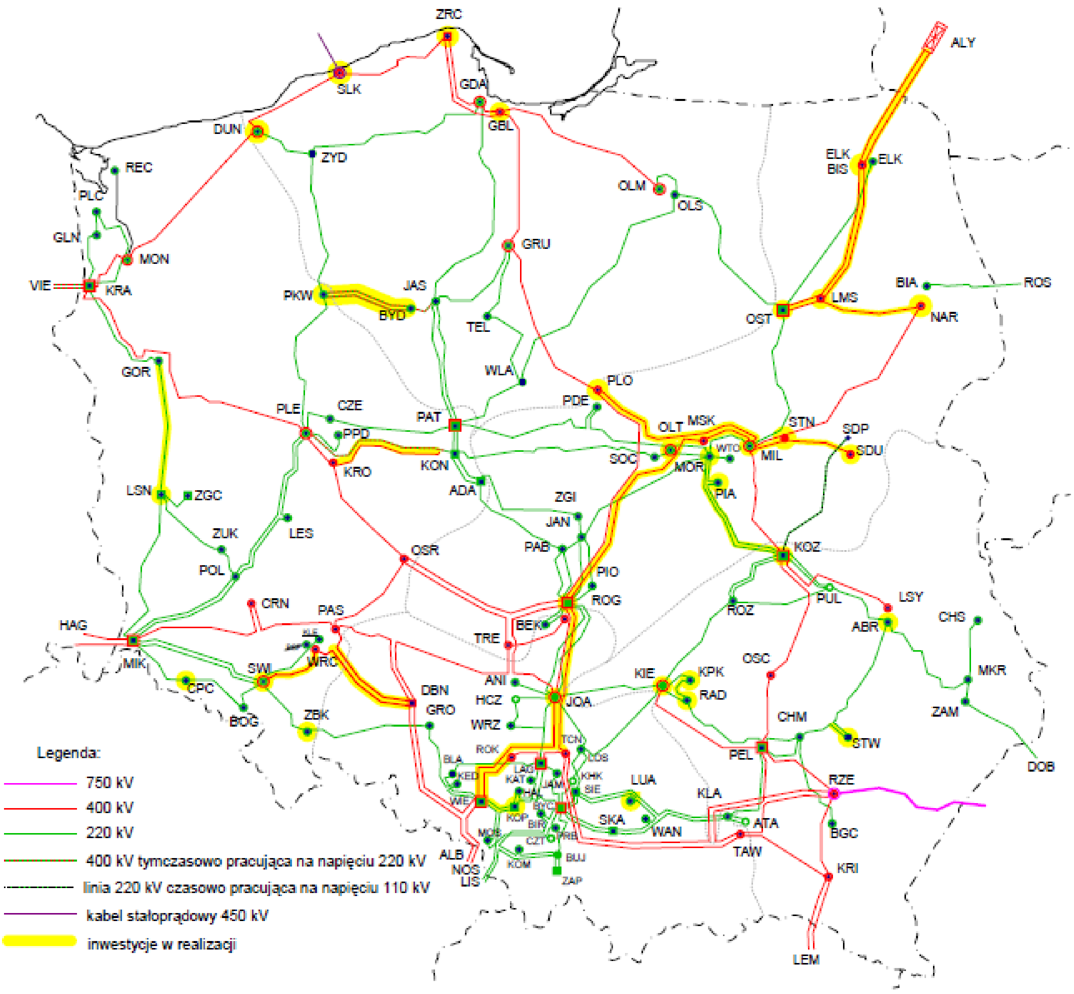
Annex 4. Grid development plans of the 50Hertz TSO



Annex 5. Map of the current Danish transmission grid

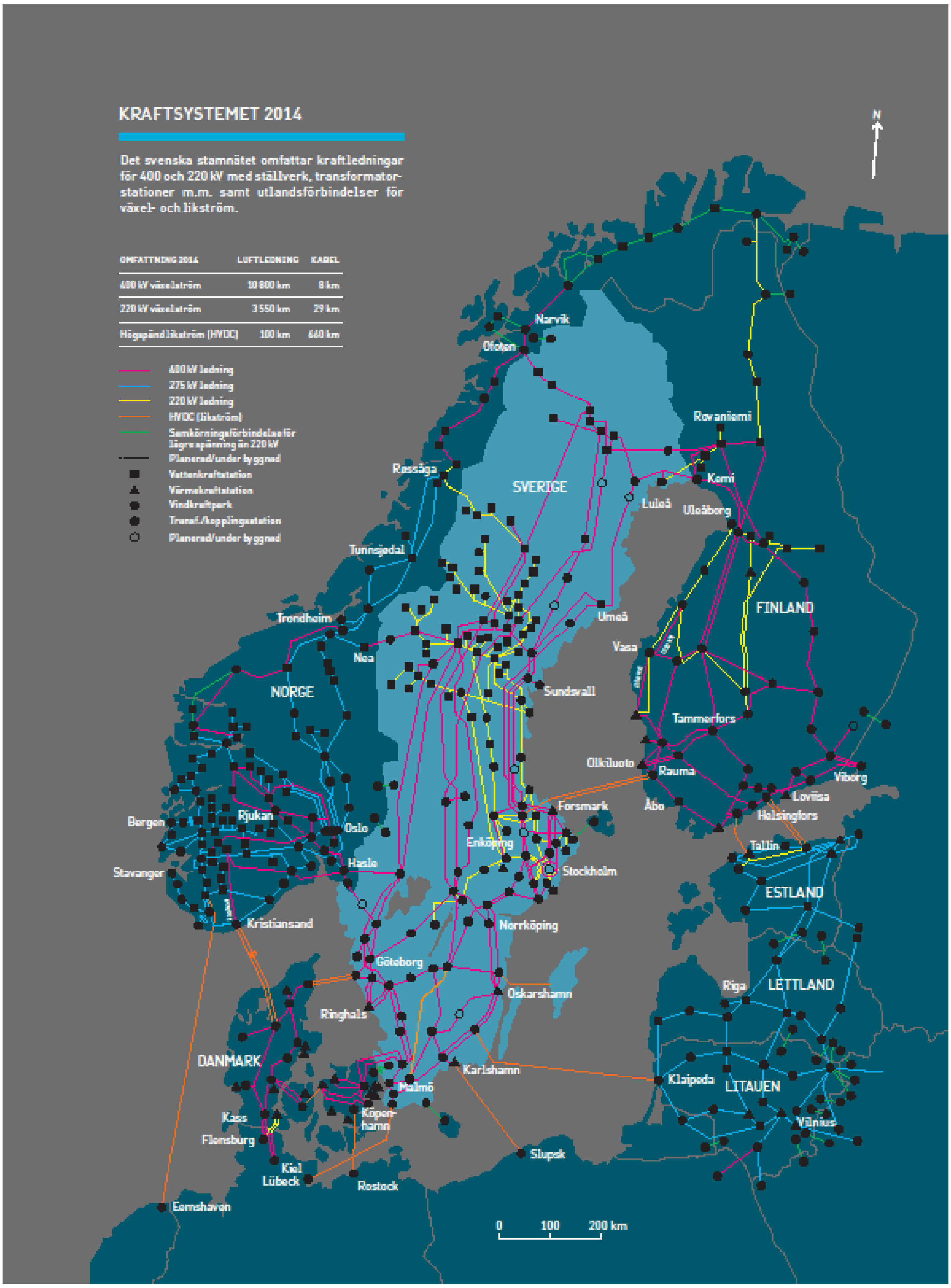


Annex 6. Map of the Polish transmission grid as of 01.01.2013 (yellow color represents investment currently being implemented)

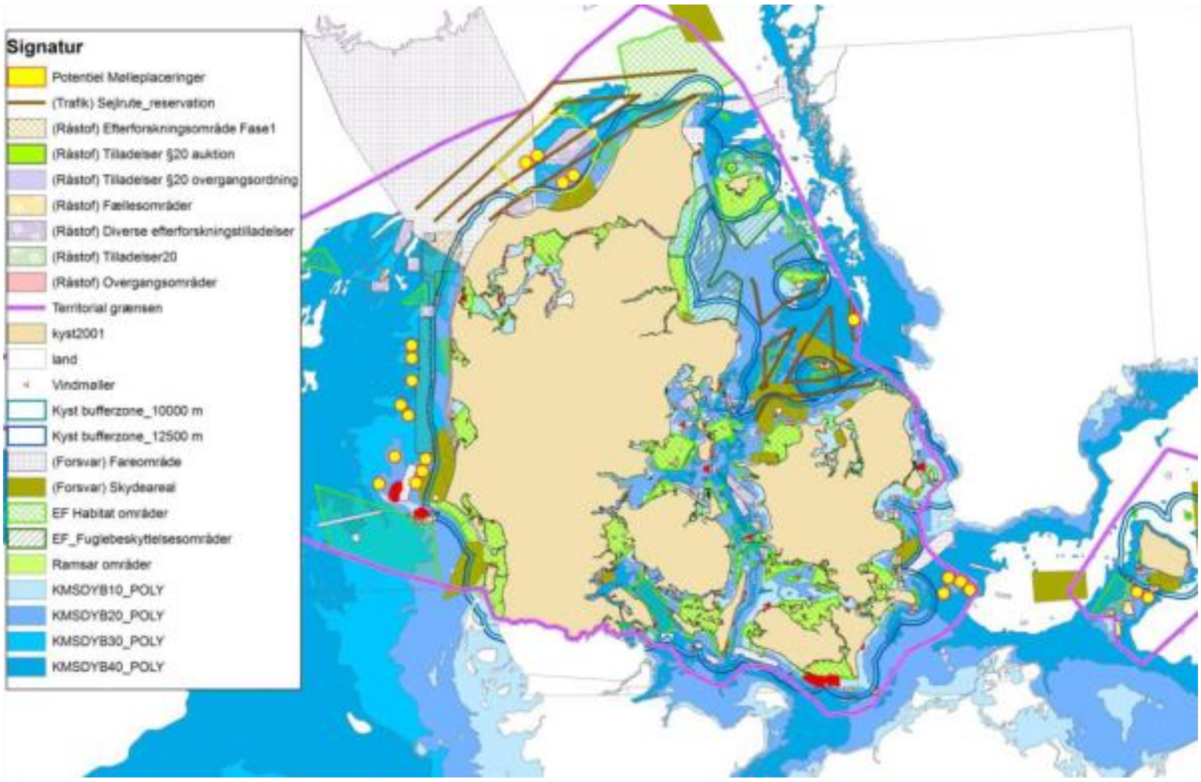


Annex 7. Map of the German transmission grid

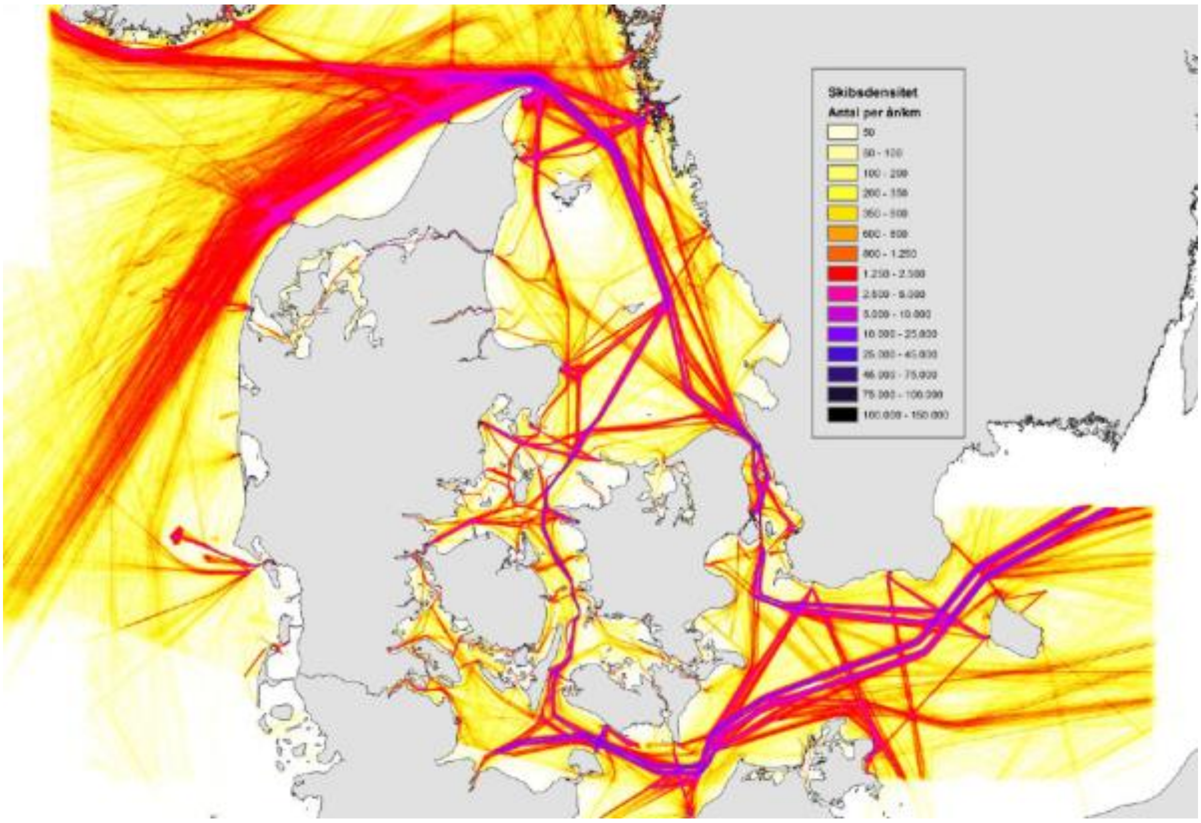
Annex 8. Map of the current Swedish transmission grid



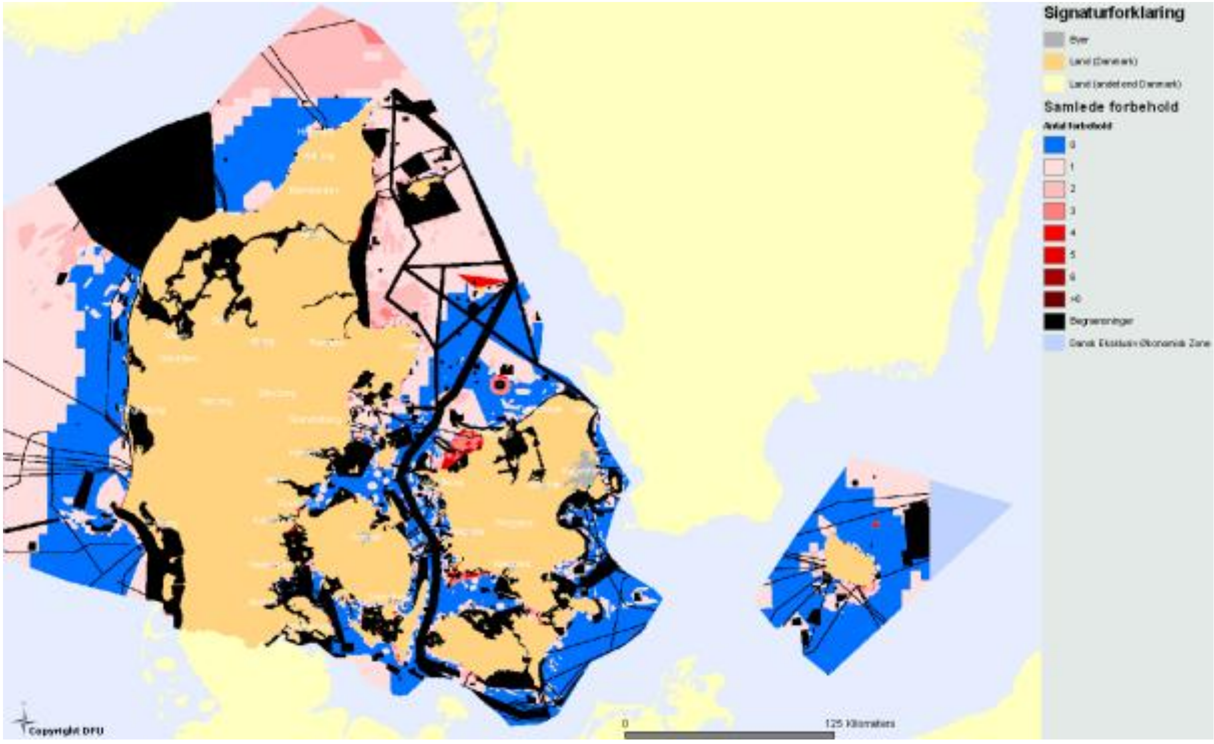
Annex 9. Maritime spatial planning in Denmark – mining areas (grey) and environmental protection areas (light green and green checkered or ruled)



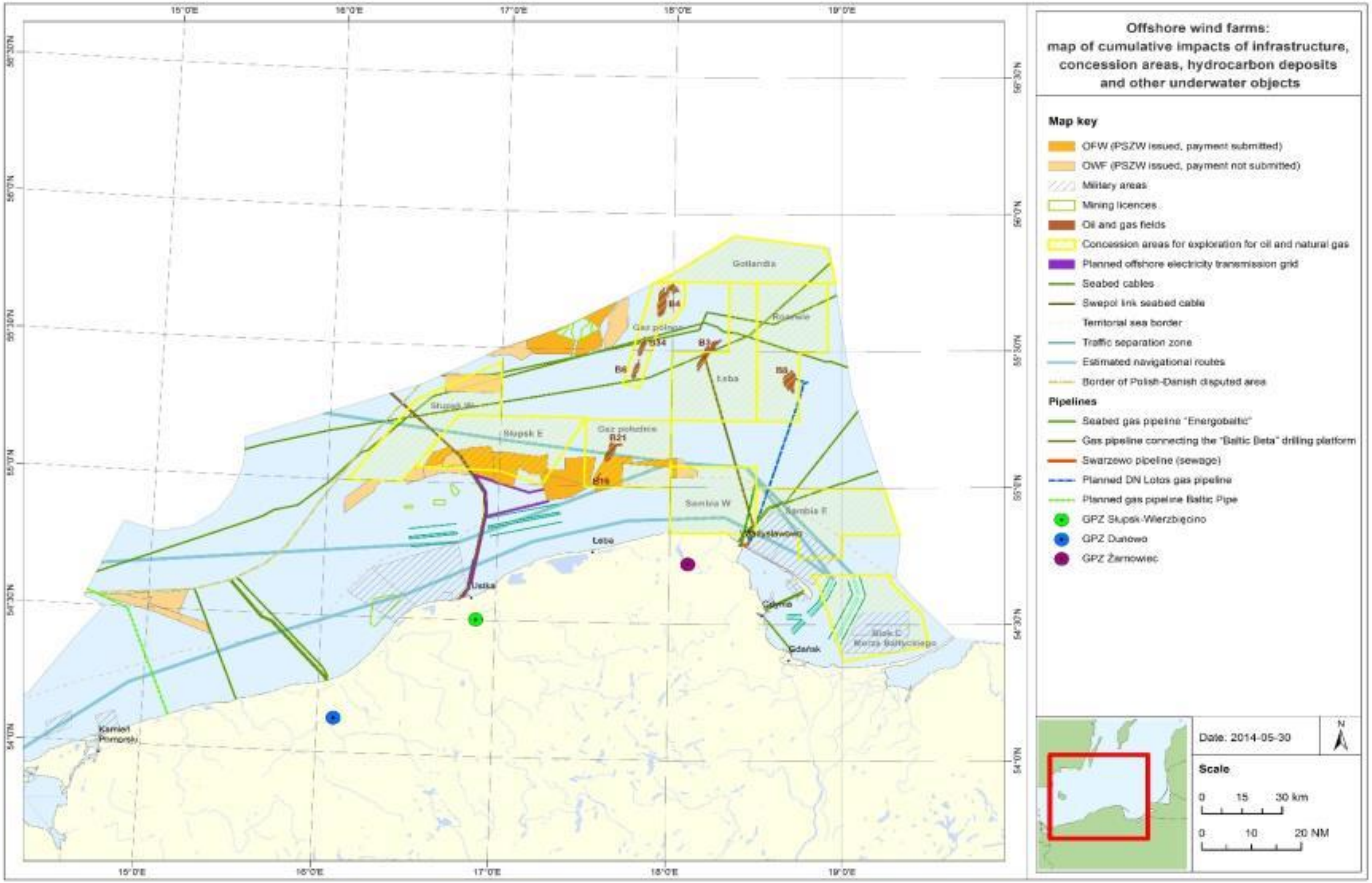
Annex 10. Major shipping routes in Danish waters



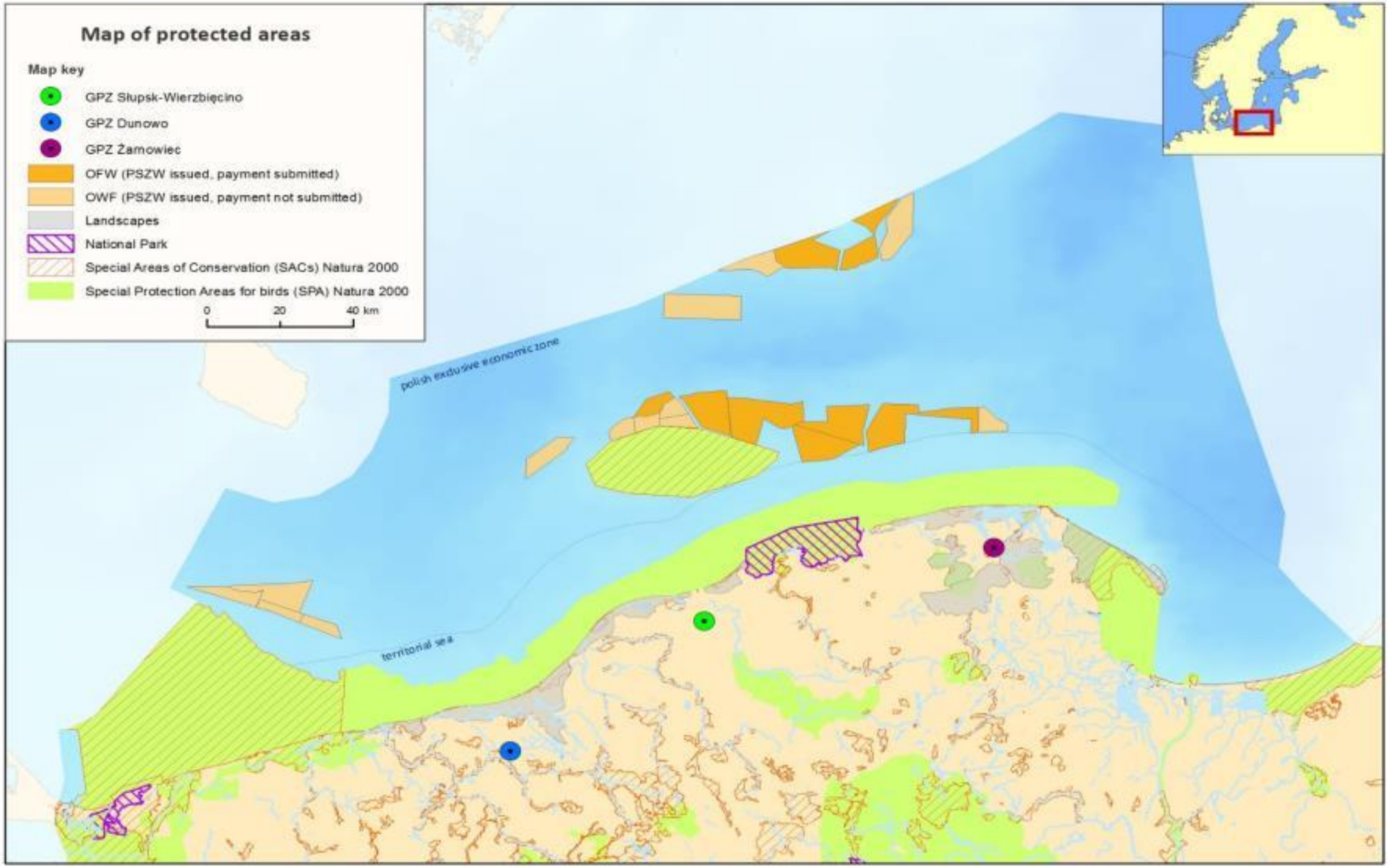
Annex 11. Map of the different uses of Danish maritime areas



Annex 12. Map of known barriers for subsea cables in Poland

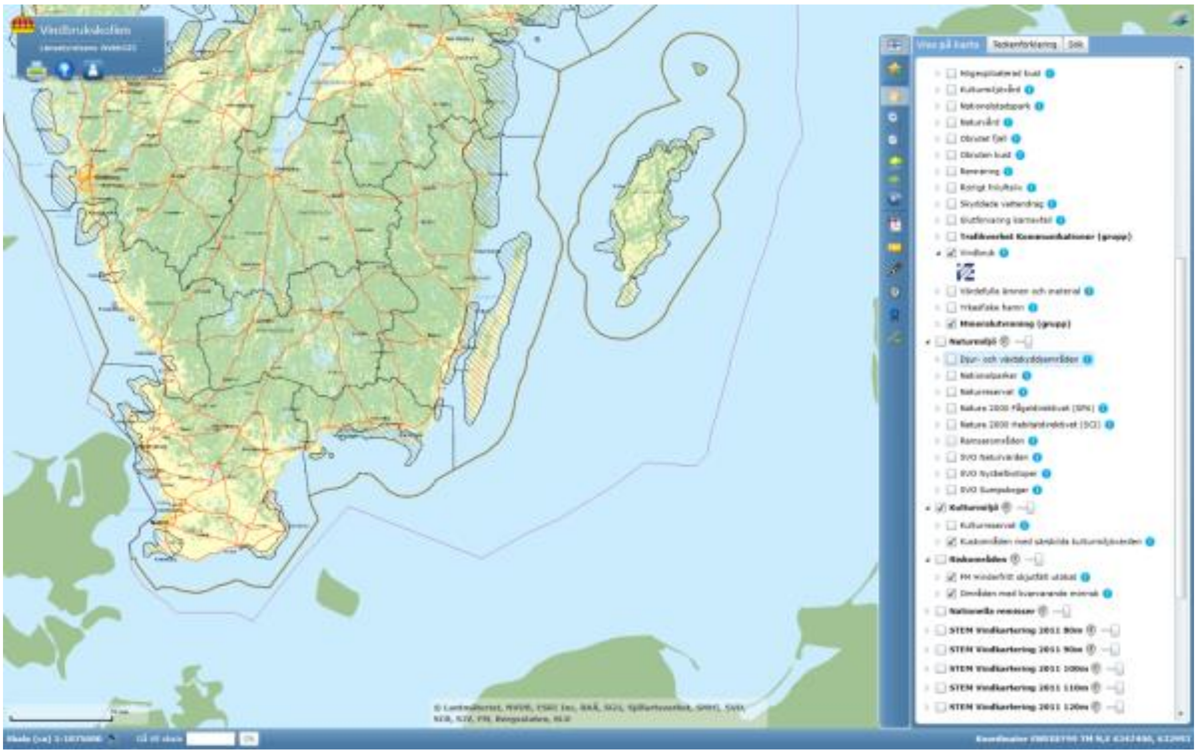


Annex 13. Map of protected areas in the Polish sea

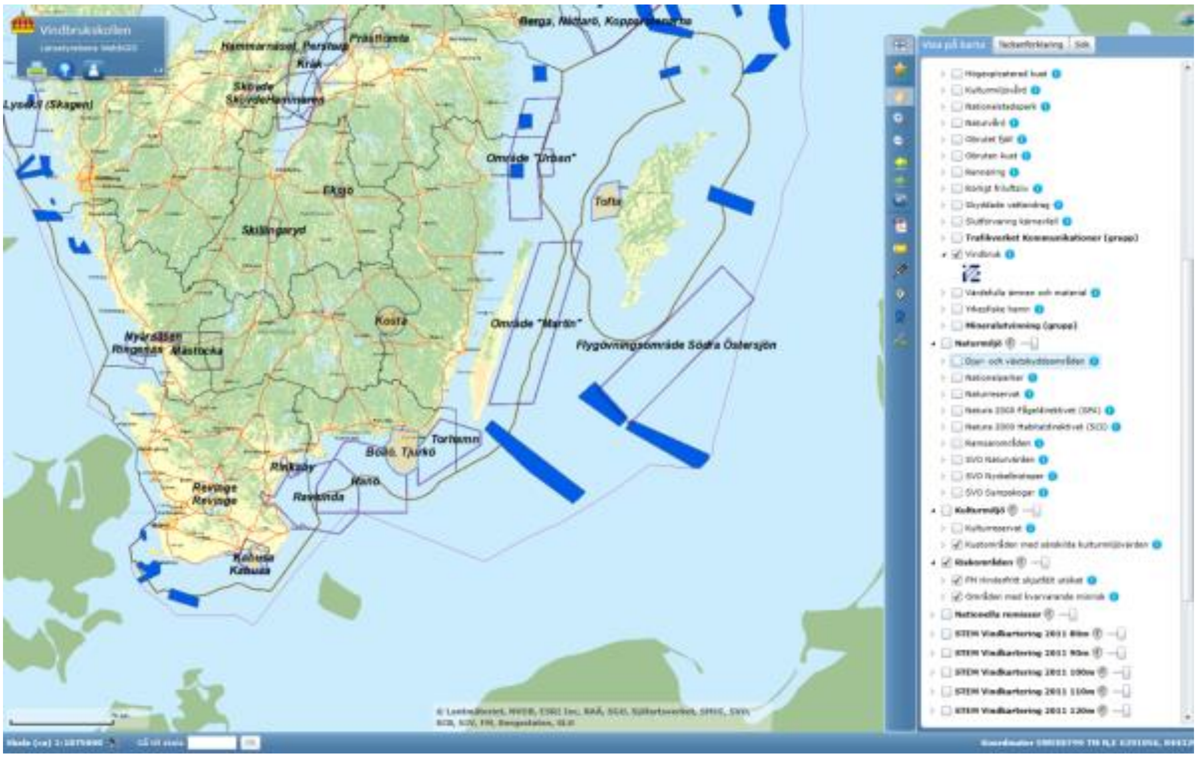


Annex 14. Spatial management plan of German maritime areas

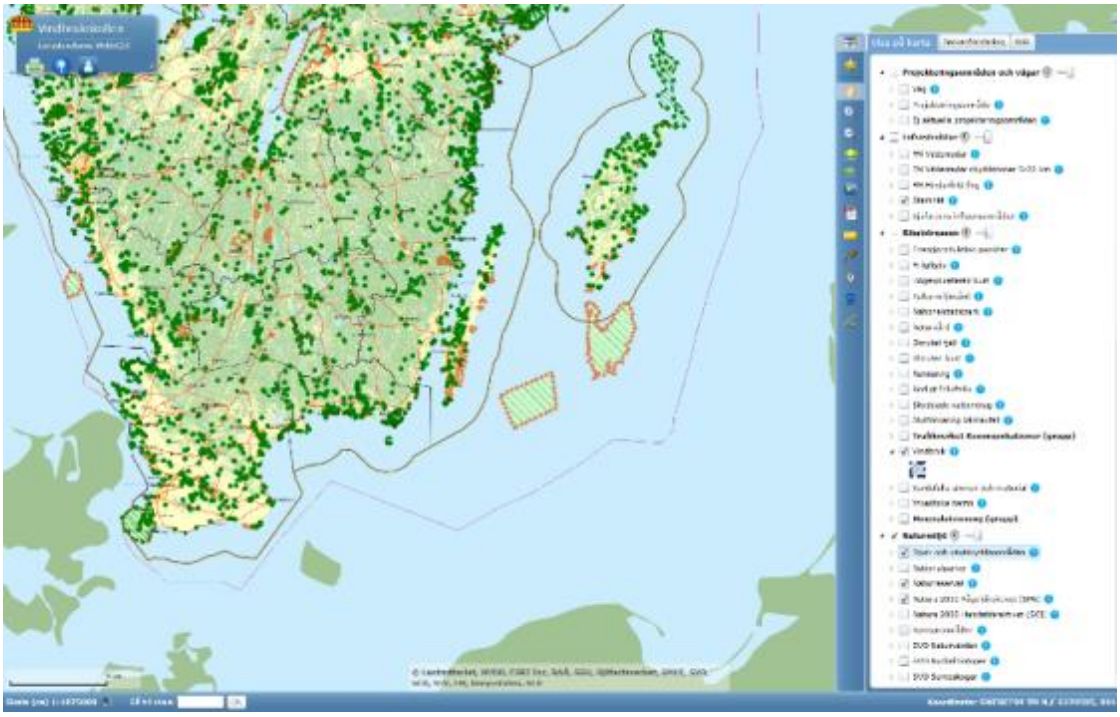
Annex 15. Area restrictions in Sweden due to valuable landscape, culture and tourism



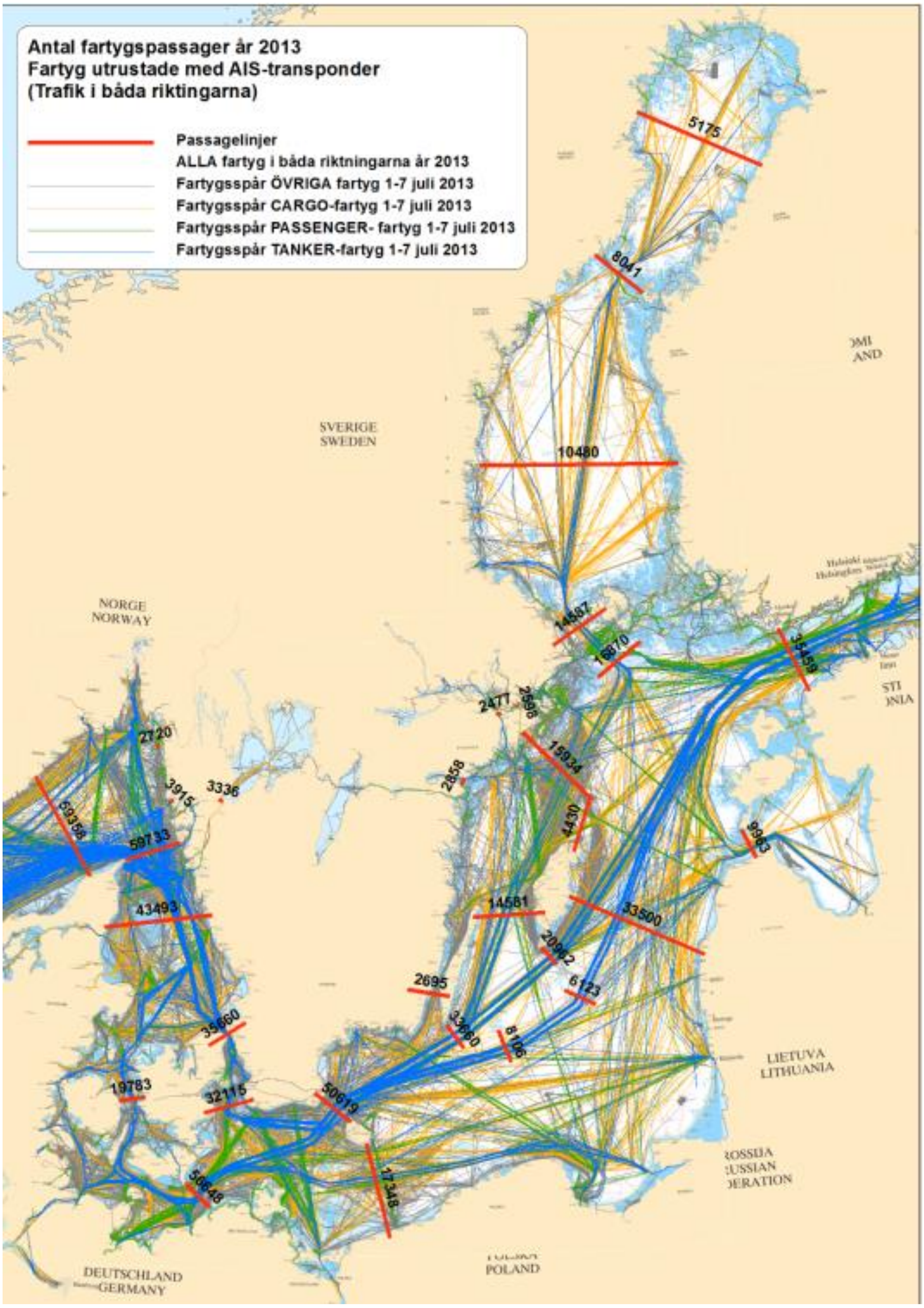
Annex 16. Area restrictions in Sweden due to old mines (blue) and military training areas



Annex 17. Area restrictions in Sweden due to nature and wildlife



Annex 18. Traffic in the Swedish part of the Baltic Sea



4. Figure list

5. Table list

6. Appendices